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NONFUEL MINERAL RESOURCES OF THE PUBLIC LANDS. VOLUME VI: MINERALS AND THE ENVIRONMENT; MINERAL LAND SYSTEMS; APPENDIX AND SUMMARY

George F. Leaming, et al

Arizona University
Tucson, Arizona

December 1970

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NONFUEL MINERAL RESOURCES OF THE PUBLIC LANDS

Volume VI

Minerals and the Environment

Mineral Land Systems

Appendix and Summary

A Study Prepared for the
Public Land Law Review Commission

by

The University of Arizona
Tucson, Arizona

Republished with revisions
December 1970

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NONFUEL MINERAL RESOURCES AND THE PUBLIC LANDS

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MINERALS AND THE ENVIRONMENT

Prepared for
The United States Public Land Law Review Commission

by

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Tucson, Arizona

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Public Land Law Review Commission

NONFUEL MINERAL RESOURCES OF THE PUBLIC LANDS
Volume VI: Minerals and the Environment; Mineral Land Systems; Appendix and Summary

The University of Arizona
Tucson, Arizona

Republished with revisions December 1970

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CHAPTER 10

MINERALS IN THE MARKET

Has the marketing of nonfuel minerals changed since the 1860's? Do different mineral commodities now have varying market characteristics? Can these be expected to change by 1985?

A. MINERAL MARKETS IN THE 1800'S

1. The Marketing Process

The marketing of mineral commodities in the United States in the latter half of the 19th Century strongly reflected the nation's relatively simple industrial structure (compared to today) and close economic ties with Europe. The relatively small number of mineral commodities that were commercially useable also tended to simplify the mineral marketing process. Gold, the principal metal mined in the United States prior to 1872, was sold pretty much to whomever would buy. Much of the early mineral marketing for gold was actually conducted on a barter basis, with the mineral commodity used as money in exchange for goods and services. In addition, considerable amounts of gold were shipped from the West to the Eastern United States for sale to the federal government and to private financial institutions. Gold was almost always marketed in metallic form, with virtually no significant trade in gold ores or concentrates. Custom milling was practiced, however. Most ores of other metals, principally copper and silver, were sold to others to be further processed from the raw ore or concentrates. Very little mineral output was sold directly to industrial users, but was channeled through custom smelters or commodity trading firms. Commodity exchanges were also important in the marketing of mineral products in the late 1800's. These involved both merchant and agent middlemen dealing not only in current, but also in future mineral transactions. Speculation in mineral marketing was rife.

Transportation was an extremely important part of the mineral marketing process in the late 19th Century and has remained so to this day. In the early years of lead mining in Southeastern Missouri, mineral sales suffered severely from a lack of adequate railroad facilities. This hindered the importation to the mining district of supplies and mining machinery as well as shipments of lead from the area to eastern markets. Initially, shipments of lead pigs from Southeast Missouri had to be hauled over a rough wagon road to a railway station approximately 15 miles from original mining operations. In the spring and autumn, teams of from four to six mules had to drag the wagons loaded with 20 or 30 pigs of lead painfully and slowly through the seasonal sea of Missouri mud. The haulage became so difficult at times that the cost of transportation became greater than the final market value of the lead. In 1880, however, a narrow gauge railroad under the joint ownership of two local mining companies was completed to the mine operations. The arrival of the railroad greatly facilitated the marketing of mineral commodities from the Southeastern Missouri area.

Both main line and connecting railroads were also important factors in the marketing of mineral products from the copper mines of Montana and Arizona and from other metallic mineral deposits throughout the entire Western United States. Water transportation was likewise important in the marketing of nonferrous metals from the West, since in the early years before the coming of the railroad, many shipments of metal concentrates had to be made to European smelters. Shipments of copper ores and concentrates from the West to the smelter at Swansea, Wales, were common, though expensive.[1]

Developments in transportation and commodity marketing outside of the West also had profound effects on the marketing of minerals produced in the Western United States. One of the most significant of these events was the diversion in the 1860's of a large volume of traffic from sea shipment to the newly completed eastern railroads. The mineral products of the Middle West and eastern Rocky Mountain areas had formally been shipped to the East by way of New Orleans using both river and ocean transport. With the coming of the railroads on the Great Plains, however, such commodities were then shipped directly to the more industrialized portions of the Northeastern States over the new transportation routes which bypassed the Mississippi, Missouri, and Ohio River markets. By as early as 1852, the lead trade of Iowa and Missouri had been almost completely diverted from river transportation to shipment by rail. The westward extension of the railroads to the Southwest influenced an even greater diversion of production from the previous route through the Port of New Orleans to the more direct eastern rail routes.[2]

2. Markets and Prices

The improvements in transportation that took place during the late 1800's made much greater supplies of mineral commodities more readily available to both American and European industrial markets. This served to meet an increasing demand, but it also intensified competition and generally tended to force world commodity prices down. Average railroad freight rates in the United States declined from almost two cents per ton mile in 1867 to less than three-fourths of a cent by 1899.[3] The sharp reductions in transportation costs brought mineral commodities from all sections of the country (including the Western States) into primary centers of industrial consumption in the East and transformed what had been a local market for many mineral commodities into national and international markets. With these changes, the determination of mineral prices became subject to frequent variations as a result of changes in both national and international supply and demand conditions, as well as of manipulation by both national and international mineral producers and marketers. Substantial day to day (and even hourly) variations in mineral prices on American and European commodity exchanges became common.[4]

For many of the metallic minerals produced in the Western United States, increased supplies and substantial reductions in marketing costs, as well as in the actual costs of production, resulted in many instances in precipitous price declines. From the early 1870's to the late 1880's, crude oil prices dropped from more than nine cents per gallon to less than two cents. The price of Bessemer steel rails dropped from $58 per ton at the mills in 1880 to less than $40 per ton by the end of that decade. Price manipulations and discrimination by trusts were also fundamental in the decline in mineral commodity prices during this period, perhaps even more so than the substantial increases in labor productivity that were caused by improved machinery and production methods and by decreases in transportation and other marketing costs.[5]

In 1880 the price of copper was 25 cents a pound. It had fallen to eight cents a pound by 1887. In that year, however, a European syndicate succeeded in gaining sufficient control of the international copper market to artifically double the metal price to 16 cents per pound. This higher price lasted until the end of the decade when the price dropped back to 9 cents a pound, breaking the syndicate and inflicting serious financial adversity on numerous copper producing firms in the Western United States.[6]

European market conditions were also important in the marketing of precious metals produced in the United States. The development of the Comstock Lode in Nevada, for example, led to such exaggerated stories of the mineral wealth available in that area that several European countries were frightened into the demonetization of silver and the price of silver dropped greatly in both European and American markets.[7] Continued increases in western precious metal production also had their effects. In 1871, Germany adopted the gold standard and ceased the minting of silver. In that same decade, the United States discontinued the coinage of silver dollars. The decline in silver prices in the middle 1880's was enough to virtually close down such early precious metal mining camps as Tombstone, Arizona, and Virginia City, Nevada.

Fluctuations in prices were also common with other metals. In the same era, declines in copper prices were attributed largely to increases in the production of copper as well as to reductions in the cost of mining, smelting, and marketing, resulting from improved production processes and reduced transportation rates, which in turn resulted from increased railroad construction. The discovery and rapid development of rich copper mines in Montana and Arizona and the expectations of production from those areas also attributed to the drop in copper prices. In the late 1880's, previous declines in copper prices were intensified by the decreasing consumption of copper in Europe, resulting from slack activity in ship building and various other metal-using industries.[8]

Throughout the Western United States in the late 19th Century, the time periods involved in the marketing of mineral commodities were generally lengthy, ranging from several weeks to several months for some commodities. Mineral output was also highly sensitive to price changes, and price changes themselves were quite variable. Consequently, there was considerable market risk involved in the production and sale of mineral commodities in the United States in the last century.

Real supply was one of the factors that had considerable influence upon commodity prices. This was generally amplified by exaggerated ideas of potential increases in supply caused by bonanza stories that emanated frequently from the Western States. Panics caused by over-pessimism and booms caused by over-optimism regarding the value of mineral districts were quite common. Actual increases in supply were, of course, also influential in their effects on commodity prices and upon the subsequent utilization of the West's mineral resources.

In the late 1800's, with few exceptions, there was very little difference among the metallic minerals as far as the marketing environment was concerned. Government policies with respect to precious metals were, of course, most influential although tariffs and other protective devices were also important in the market for base metals. These were particularly significant with respect to the marketing of iron and steel. Markets for industrial minerals were influenced principally by local conditions, and these were quite variable from one locality to another.

Table 0

MARKETING CHANNELS FOR COPPER PRODUCED IN THE UNITED STATES, 1967

Marketing Firm	Sells Copper Produced by:
American Metal Climax, Inc., United States Metals Refining Division	American Metal Climax, Inc.
Ametalco, Ltd., (London) through Ametalco, Inc. (subsidiary)	Pima Mining Company
American Smelting and Refining Company (Asarco)	Asarco, Bagdad Copper Corporation, Duval Corporation, Pima Mining Company, and various smaller producers
Anaconda Sales Company	Anaconda Company, Inspiration Consolidated Copper Company
Calumet & Hecla, Inc. Calumet Division	Calumet & Hecla, Inc. Calumet Division
Cerro Sales Corporation	Cerro Corporation
Copper Range Sales Company	Copper Range Company, White Pine Copper Company
International Minerals and Metals Corporation	Magma Copper Company and various small producers
Kennecott Sales Corporation	Kennecott Copper Corporation
Adolph Lewisohn Sales Division Tennessee Corporation	Tennessee Copper Company Division and Miami Copper Company Division of Tennessee Corporation
Phelps Dodge Sales Company, Incorporated	Phelps Dodge Corporation and subsidiary companies; also custom smelted and refined copper from other producers
Quincy Mining Company	Quincy Mining Company

Source: American Bureau of Metal Statistics.

B. MINERAL MARKETING SINCE 1947

1. The Marketing Process for Metals

Since the end of World War II, much of the marketing environment for mineral commodities has changed, and yet much has stayed essentially as it was in the late 1800's. With respect to metallic minerals, each mineral commodity in reality has its own distinct marketing mechanism and market characteristics. The marketing of no mineral commodity is exactly like that of any other. Sometimes the differences between commodities are influenced more by tradition than by existing circumstances, but in most cases the different marketing mechanisms have developed over the last 100 years because of the specific features of the problems involved in producing and consuming the individual mineral commodities.

In the marketing of metallic minerals, a market may actually exist at several points along the continuum from crude mineral production to ultimate consumption. Some metallic ores are not converted into metal at all but are sold by the miner or dealer in mineral concentrates directly to industrial consumers. An example of this is the marketing of ferrous additive ores concentrate directly to the steel industry without the intermediate production or sale of the alloying metal.

For certain metals, a significant portion of the amount consumed and purchased by utlimate consumers is in the form of scrap. Some mineral commodities lend themselves more readily than others to penetration by scrap in the total mineral market. Iron and lead are both in this category. Scrap iron has been of substantial importance primarily because of its use in the steel-making process. It has also been important because of its relative abundance and the easy availability of scrap iron resulting from obsolescence (planned or otherwise) in the nation's automobile market. Related closely to this is the importance of scrap lead in the total market for lead in the United States.

Today, much of the production of metallic mineral commodities is integrated vertically, so that the large miner of metallic ore has considerable control over the sale of the finished metallic commodity. This is true, however, only with the major metals. For the alloying metals, only a small proportion of total mineral production is carried through to the refined metals themselves. The ores or concentrates of these metals are normally sold either directly by the miners to the industrial consumer or through dealers. For the minor metals, dealers are still an important part of the minerals marketing environment in the United States. These same dealers also buy and sell many of the crude mineral commodities imported from overseas sources.[9]

2. Industrial Minerals Markets

It is virtually impossible to establish accurate generalizations regarding the marketing of industrial minerals, except perhaps that generalizations are always inaccurate. Some features of the marketing environment are reasonably common to most industrial minerals markets, however. The first of these is that nearly all industrial minerals markets are local or, at most, regional in nature. This is true to a certain degree even of phosphates, with the only significant exceptions in the United States being potash and sulfur, which tend to serve national and often international markets.

For the most part, the marketing of industrial minerals is done by the producers themselves, and the use of sales agents, jobbers, and other middlemen is much less prevalent now than in the past. In many instances, the minerals producer is the seller of the finished product to an industrial consumer or industrial materials dealer. For example, in the marketing of gypsum, very little is sold as a crude mineral commodity. Rather, wallboard and plaster are normally made from the raw gypsum mined by the producer, and these manufactured products are then sold to construction firms or to building materials dealers

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who in turn sell them to building contractors or to homeowners, who are in effect the ultimate consumers. Crude gypsum for use as a retarder in the manufacture of portland cement is usually sold by producers directly to cement producing companies. Special plasters for use in the production of pottery, paint, glass, and other products are usually sold by the minerals producers directly to plaster or chemical materials supply houses or to the manufacturers of those particular end items. Gypsum for use in agriculture as a soil conditioner is normally sold by producer sales organizations directly to fertilizer mixing plants, farmers cooperatives, or farmers themselves.

In similar fashion, phosphate rock for use in fertilizers is frequently converted to fertilizer form by the minerals producer mining the crude rock. These fertilizers are then often sold directly to individual farmers, fertilizer dealers, or farm cooperatives. In some cases, a fertilizer company may buy treated phosphate rock from a mine operator and use it in the further manufacture of fertilizer. Phosphate rock used for making phosphorus chemicals is usually processed by the mineral producer, with the resulting chemical products sold directly to the consuming industries.

In normal times, approximately 90 percent of the phosphate rock mined in the United States is consumed in the manufacture of phosphate compounds for manufactured fertilizers or for direct application to the soil. Since most phosphate rock is mined principally for the benefit of agriculture, variations in domestic crop agriculture have a significant impact upon the market for mineral phosphates. The expanded use of chemical fertilizer materials in foreign countries, particular around the Pacific Basin, likewise has had a significant impact upon the marketing of phosphate minerals mined in the Western United States.[10]

As with many other mineral commodities used in the construction industry, a large part of all of the crude asbestos produced in the United States comes from the mines and mills of companies that also manufacture the finished products. Independent producers that sell only crude mineral commodities form an exceptionally small part of the industry. For much of the output of the nation's industrial mineral commodities, therefore, the producer is also the chief industrial consumer, and mineral marketing involves the marketing of finished consumer or industrial products rather than of crude minerals. Nevertheless, there are still substantial tonnages of crude construction materials such as asbestos sold to other manufacturers by the integrated mineral producers as well as by independent mining firms that market raw commodities only. Agencies and representative firms handle part of this marketing of crude mineral materials and often act as jobbers for the distribution of small lots.

Like other industrial minerals, the marketing of limestone depends entirely upon the utlimate use to which the limestone is to be placed, and varies from no distinct marketing at all, as in the case of captive quarries owned by steel and copper producers, to direct marketing to household users, as in the case of some limestone used as crushed stone.

Limestone serves as an excellent example of the wide range of uses to which industrial minerals may be put and the various forms in which they are marketed. Limestone is produced for market in essentially two forms – either as large blocks or as crushed or broken rock. The most important characteristics of limestone used in large blocks as dimension stone are its physical characteristics, including color, texture, permeability, compressive and tensile strength, hardness, abrasive quality, and lustre. In this form, the chemical properties of the rock are of lesser importance, but the inclusion of chemical impurities such as pyrite nodules would be objectionable for several physical purposes. The relative importance of the various qualities of the stone relate directly to its use as an interior or exterior construction material or any other use it may have.

Market specifications applicable to crushed or broken limestone also relate directly to the ultimate use of the product. The specific requirements have increased during recent years as a result of the evolving technical change in various industries. In the construction industry, both the American Society for Testing Materials and the American Association of State Highway Officials have written extensively regarding specifications for crushed stone.

The principal *physical* properties of crushed rock aggregates which affect their behavior when used as structural materials include hardness, resistance to weathering, particle shape, size, toughness, cleavage, density, composition, porosity, color, and crystalline structure. The chemical industry, on the other hand, usually requires uniform *chemical* composition in the limestone that it buys, with few impurities or with only impurities of a specific nature and quantity.

The market for limestone is in reality a series of markets for a wide variety of distinct mineral commodities. For example, a vast tonnage of limestone is used as aggregate for concrete, chiefly in highway and building construction. Although individual consumers may differ in some respects as to the particular qualities of stone needed for use as concrete aggregate, the rock so used generally should consist of clean, hard, strong, durable, uncoated fragments free from injurious amounts of soft, friable, thin, elongated, or laminated pieces. Alkalies and organic matter are also usually undesirable. Soluble sulfides are likewise objectionable, because the oxides and the sulfuric acid formed will attack the calcareous materials present and form gypsum, which expands during crystallization and disrupts the concrete. Numerous physical and chemical tests are made to ascertain the fitness of the limestone for use in aggregate.

Large quantities of crushed limestone are used by railroad companies as ballast for maintaining road beds. In this use particle size is extremely important, while other requirements as to the physical quality of the mineral commodity used are generally the same as for concrete aggregate and road metal.

Limestone dust fine enough so that approximately 80 percent of it will pass through a 200 mesh screen (200 openings to the inch) is used as a filler in asphalt road surfaces mixtures. Much of this material is actually sold as a by-product from crushed stone plants, while the preparation of such asphalt filler forms a substantial part of the business of other quarrying companies. Operators of bituminous coal mines also employ fine, incombustible dust for distribution throughout underground workings on the surface of walls, bottom, and back, as a means of preventing or checking coal dust explosions. Limestone dust is particularly satisfactory for this purpose, because it is essentially not combustible, not injurious to the lungs, and (being white) is readily discernible. Furthermore, it tends to suppress combustion when disturbed. To comply with the Federal Coal Mine Safety Act, rock dust must contain not more than five percent of free and combined silica and must be ground so that 100 percent will pass through a 20 mesh screen and 70 percent or more will pass through a 200 mesh screen. Thus, size and other physical properties as well as chemical composition are also important in this use for limestone.

Riprap consists of large, heavy, irregular blocks used chiefly for river and harbor work, for spillways at dams, and for shore protection. It is a low-value use requiring low-priced product, and rock for riprap is usually procured from nearby quarries, almost as scrap. Any type of dense, sound limestone may be used for riprap, and there are no general specifications other than size.

Crushed limestone is often used for sewage filter beds. Either high calcium or dolomitic limestone may be so used, and siliceous impurities are not objectionable if they are fine-grained and evenly distributed. Certain other impurities, notably pyrite, marcasite, and clay are to be avoided, however. The stone so used should be strong and compact with pore space evenly distributed, and the fragments should be rough to provide an anchorage for bacteria. Fines and dirt should be screened out. Thus, both chemical and physical properties are also important in this use for limestone.

Dense, compact limestones of attractive colors may be crushed to small fragments for terazzo floors, but marble chips that will take a polish are generally preferred. Limestone that is reasonably impervious to moisture also finds some use in stucco and other finished masonry. Limestone crushed to the size of sand grains, when carefully washed and graded, may be substituted for silica sand in mortar, wall plaster, and concrete. Large tonnages of limestone sand have been so used in concrete highway construction, particularly in the Middle West where silica sands are relatively difficult to obtain. In other construction uses, screened limestone chips are often sold as gravel to be used with tar for coating flat roofs. Such use is common throughout the Southwest.

Limestone screenings without a binder afford good surfaces for school yards, playgrounds, and walkways. Limestone screenings are likewise used as aggregate in the manufacture of concrete blocks, and limestone chips may even be imbedded in the surface to make the blocks resemble cut stone.

Chalk is a soft, friable, fine-grained, light-colored type of limestone. The distinguishing physical characteristics of true chalk have never been fully defined, but its noncrystalline and colloidal properties are presently considered most important. *Whiting* is a pulverized, purified, and carefully sized chalk. Whiting substitutes consist of finely ground limestone or dolomite, ground marble, white marl, and chemically precipitated calcium carbonate. Very little true chalk has actually been produced in the United States. True whiting is preferred for calcimine and cold water paints, and in the manufacture of putty. Both true whiting and substitute materials are used as ceramic raw materials and as fillers in numerous products, including rubber, paint, paper, oilcloth, and linoleum.

Limestone is the chief raw material used in making portland cement. While pure limestone is not required for this market, consistency in chemical composition is desirable. The general requirements for limestone to be used in portland cement manufacture are several. The stone should be free of concretions, and low in iron minerals. The silica and alumina contents of the limestone should be sufficiently low and in such proportions that they will not interfere with the desired silica-alumina ratio in the finished product. Furthermore, the magnesium content should be low enough so that the finished product will not contain more than five percent magnesia. Similarly, the content of iron in the original limestone should be low enough so that the ferric-oxide content of the cement does not exceed four percent. In addition, the sulfur content of the original limestone should be low. Limestone used in cement manufacture is usually argillaceous limestone that naturally contains enough clay to adapt it for the manufacture of cement. Sometimes, however, it is necessary to adjust its composition by adding small quantities of either high calcium limestone or clay.

For lime manufacture, limestone must conform to rather rigid physical and chemical requirements alike. Exceptionally pure stone, having total carbonates ranging from 97 to more than 99 percent, is generally used for the manufacture of lime, because virtually all metallic impurities remain in the burnt lime output of the calcination process. The most common impurities in such stone are silica, alumina, iron, and sulfur. Both high calcium and high magnesium limestones are used in the manufacture of lime.

The most important uses for limestone in agriculture are with fertilizer, as a soil conditioner, and to neutralize excessive soil acidity. Pure limestone is desirable but not essential for agricultural purposes because while ordinary impurities lessen the proportion of contained calcium or magnesium available for improving the soil, the impurities themselves are not injurious to plant growth. As a result, it may be more economical to use a locally available impure limestone rather than to purchase higher-grade material that must bear a heavier transportation charge. Although there is some difference of opinion regarding the suitability of dolomitic limestone for agricultural purposes, most authorities agree that magnesium is of equal value with calcium in off-setting acidity in soils and that the value of stone for agricultural purposes may be measured by the percentage of total carbonates present. Dolomitic limestone is, of course, preferred for magnesium deficient soils. Small quantities of limestone are also used in commercial fertilizers as diluting materials or fillers.

Limestone is not limited in its agricultural uses to service as a soil conditioner. Limestone crushed to small granules and screened to uniform sizes is also sold for poultry grit. Almost any small size of limestone may be so used, but the products are usually graded according to finished sizes into turkey grit, chicken grit, pigeon grit, and bird grit (for canaries and similar small birds). Pulverized limestone is also added to stock food as a bone builder in addition to being used as poultry grit.

The name *mineral wool* or *rock wool* is commonly applied to interlaced threads or filaments of material silicate used chiefly in heat insulation. The product is usually made by melting argillaceous limestone, slag, or other calcareous and siliceous compounds in cupola furnaces and blowing the molten material into fine threads with a steam jet. The combination of raw materials most desired is one that will melt into a liquid slag at a relatively low temperature. Substantial quantities of siliceous and argillaceous limestones are used in this process.

Limestone is also an important raw material used in metallurgy, in many chemical processes, in the processing of sugar and paper, and in the manufacture of glass. All of these various uses of the rock known as limestone involve different market characteristics and present different marketing problems for the mineral producer. The largest primary uses of limestone utilize the rock in relatively untreated form, but this does not mean that most limestone is marketed as crude rock. Vertical integration in the production of industrial mineral commodities for use in various construction materials is quite prevalent. For these as well as other markets, the specifications of the purchaser dictate the various characteristics of the product sold by the minerals producer.

The major differences between the marketing of metallic minerals and industrial minerals involve the nature and extent of the market, the establishment of prices, and the preparation of the materials for sale. The marketing of industrial minerals is frequently hampered by the non-existence of a dependable quoted market price for the mineral product involved. There is no open commodity market for most individual mineral products, and prices for the great majority of the industrial minerals are negotiated prices. Although there may be published commodity prices for certain items, these published prices often bear little resemblance to reality.

Probably one of the better examples of the contrast between the marketing of a metallic mineral and an industrial mineral is furnished by the mineral *chromite*. The metal, chromium, is used in metallurgy and chromite, therefore, is a metallic mineral when considered as a source of chromium. Prices for metallurgical chromite are well known and are dependent mainly on the chrome-iron ratio of the ore. A deposit of chromite to be used in the production of chrome can therefore be evaluated with less difficulty because the expected product has a well-defined market price, and the grade of ore may be determined readily by chemical analyses. In strong contrast, however, is the situation in which chromite is used as an industrial mineral in the production of refractories. When used in refractories, the chromite must contain a high proportion of alumina, and depends for its value not only upon its chemical composition but also on its physical properties. Normally, the specifications for these vary significantly from one potential consumer to another. In fact, the physical requirements for refractory chromite depend principally on the suitability of the refractory chrome ore for the particular processing technique which has been developed by an individual consumer. The processing techniques of one consumer directly influence the physical requirements of that consumer, and most often they are not those of another. A refractory chromite deposit thus might contain a commodity which has no accepted commodity price and no generally accepted specifications (either chemical or physical) for the product. This situation is common in industrial minerals markets.

In the marketing of industrial minerals, those factors of primary concern are the location and size of the particular local markets (existing or potential), the chemical specifications for the product, the physical specifications for the product, and existing or potential prices. The means of market penetration used or to be used are also of critical importance. The product must be deliberately *sold* to the potential consumers. An industrial mineral will normally not sell itself, as will gold, silver, copper, or most other metallic minerals.

3. Mineral Prices

Negotiated, rather than open market, prices are the rule rather than the exception throughout the entire nonfuel minerals industry. Even in the marketing of nonferrous base metals such as copper, lead, zinc, iron, and aluminum, large transactions involving bulk lots often involve negotiated prices which may differ markedly from the quoted prices on commodity exchanges or those published for normal lot sizes. The published prices for tungsten, manganese, chrome, and other additive metals that are usually sold as concentrates and only rarely utilized in their refined form are frequently only approximations of the bases on which transactions actually occur. Individual negotiations between buyer and seller determine the unit and total price for each sale. It is, in fact, common with the additive metals to have several different product prices quoted. There are prices for ores, for high-grade concentrates, for iron alloys (such as ferro-molybdenum, ferro-manganese or ferro-nickel), for relatively pure chemical compounds (such as molybdenum oxide or molybdenum sulfide), and for the metal itself. Prices for ores are usually quoted in terms of the content of a particular compound, such as percent tungsten oxide, uranium oxide, or beryllium oxide. In many cases, there are also different prices quoted depending upon the manner of packaging. Sometimes there are prices for concentrates or compounds shipped in drums, in bulk carloads, in bags, or in other types of appropriate containers. There are also different prices quoted for the size of the shipment, be it for one ton or less, for a carload lot, or for more (or less) than one carload. For some metals, the shape of the finished product also effects the price paid for it.

Among virtually all of the metallic minerals, prices are highly volatile, despite the fact that some periods of relative stability have been maintained at least for the published prices of some commodities. Copper prices are usually quoted for actual sale in carload lots on a delivered basis, f.o.b. the destination in the United States. Published prices, however, are usually quoted as of either New York or the Connecticut Valley. For electrolytic copper, prices are also quoted for what are considered standard shapes. The price of lead, on the other hand, is traditionally quoted delivered in carload lots at either New York or St. Louis, with a transportation differential maintained between the prices. Deliveries at most other major consuming points made at New York price. Prime western zinc, the established standard grade in the zinc-using industry, is normally sold by producers in cardload lots delivered to consumers' plants at a price based on transportation from refineries in East St. Louis, Illinois.

In the marketing of iron ore, there has been for many years a published base price called the *Lake Erie Price* applicable to the iron ores produced in the Lake Superior Region of Minnesota and Michigan. This base is the price of a ton of iron ore containing 51.5 percent iron delivered at dockside in lower Great Lake ports.[11]

Prices for all of the precious metals are quoted by the troy ounce, rather than by the pound or the ton. Mercury is sold by the flask, which contains 76 pounds. Gold mines normally sell their output to the United States Government. Some gold concentrates, however, are sold to custom smelters for resale, and some gold contained as an impurity in other metals is sold and recovered as a by-product in electrolytic refining. Until recently, the price of gold produced domestically was fixed by the federal government at $35 per troy ounce, but the demonetization of gold in early 1968 has allowed the actual price to fluctuate slightly.

Because much of the silver production of the United States is now largely as a by-product in association with the production of copper and lead, much of the marketing of silver is done through the refiners of the major base metals. Silver is sold in the domestic market by base metal refineries in 25,000 ounce lots directly to industrial consumers. New York prices are quoted daily by Handy and Harmon, a company which is both a dealer and a fabricator of silver. The Handy and Harmon prices are based on transactions reported by both leading producers and consumers. Various other agencies, including trade journals, are used as sources for quotations on the prices of various metals and other mineral commodities.[12]

4. Supply and Price Relationships

Mineral commodities produced in the United States have exhibited a wide variety of price sensitivities. Undoubtedly, the supply of gold has been the least sensitive to market price changes. As shown in Figure 1, the empirically determined average relationship between gold price and supply in the United States from 1947 through 1967 demonstrated a high *price elasticity of supply,* with production varying widely throughout a period of constant price. Production data subsequent to the lifting of the controlled price on gold in early 1968, however, should reveal, over the next four or five years, a more appropriate elasticity of supply for the yellow metal.

The price elasticity for domestic silver output has been much less definite than that of gold. For the full period of 1947-1967 (as shown in Figure 2), the response of silver supply to price changes has been relatively *inelastic,* with large price changes needed to significantly increase domestic output. This long-term empirical curve, however, appears to involve several short-term relationships that are quite different. There appear to have been several short run periods (at varying discrete levels in the price of silver) when the supply of domestic silver has been highly elastic, with wide variation in output at a relatively constant price. Nevertheless, over the long run, however, the data since 1947 are indicative that large changes in price did bring about substantial increases in the supply of silver in the United States. This response of supply to price, however, apparently takes some time in which to operate, and is still limited by other than strictly economic factors, as shown by the 1967 decline in output (as a result of the copper strike) despite high prices.

The base metals have behaved much differently than the precious metals with respect to their response to market prices over the past 20 years. As shown in Figure 3, the empirical supply function for copper for the period from 1947-1966 demonstrates a strong positive relationship between price and mine output, with relatively moderate changes in price, resulting in substantial changes in the supply of the metal mined and offered for sale. The empirical supply curve calculated and presented in Figure 3 excludes from consideration 1954, 1955, 1956, 1959, and 1967, when labor disputes seriously disrupted the nation's copper production. The remaining years, however, demonstrate a strong relationship between mine output and the price of the red metal.

The same has been true of the supply function for lead in the United States, at least since 1953, as shown in Figure 4. Prior to that time, however, during the post-World War II period and through most of the Korean War, there was a rather inelastic negative relationship between average domestic price and mine output of lead in the United States. During that time, increases in price were accompanied by decreases in output, and price declines by greater production. Since 1953, however, the opposite has been the case, and supply has been directly responsive to increases and decreases in price.

The empirical supply function for zinc produced in the United States between 1947 and 1967, like that of copper, demonstrated a strong responsiveness on the part of zinc output to changes in the market price. The coefficient of correlation for the empirical relationship between zinc output and price, however, indicates that only about 45 percent of the variation in zinc output in the United States since 1947 has been directly associated with changes in the average domestic price, with the remaining variation associated with other factors. This contrasts sharply with the situation in the copper industry, where 88 percent of the normal variation in domestic mine output has been associated with changes in the average domestic price of copper. Since 1953, approximately 70 percent of the variation in the nation's mine production of lead has been positively associated with changes in the average domestic price of the heavy metal.

The amount of iron ore in the United States produced in response to changes in market prices has not been consistent over the period since the end of World War II, but has shifted upward. From 1947 to 1953, the nation's output of iron ore was positively related to the average domestic price, although only about 40 percent of the annual variation in total domestic production was directly associated with changes in the market price. In 1954 and continuing through to 1957, there was a general shift upward in iron ore prices, but the basic relationship between prices and output remained the same. A repetition of this occurred in 1958 and has continued to this date with the 40 percent of association

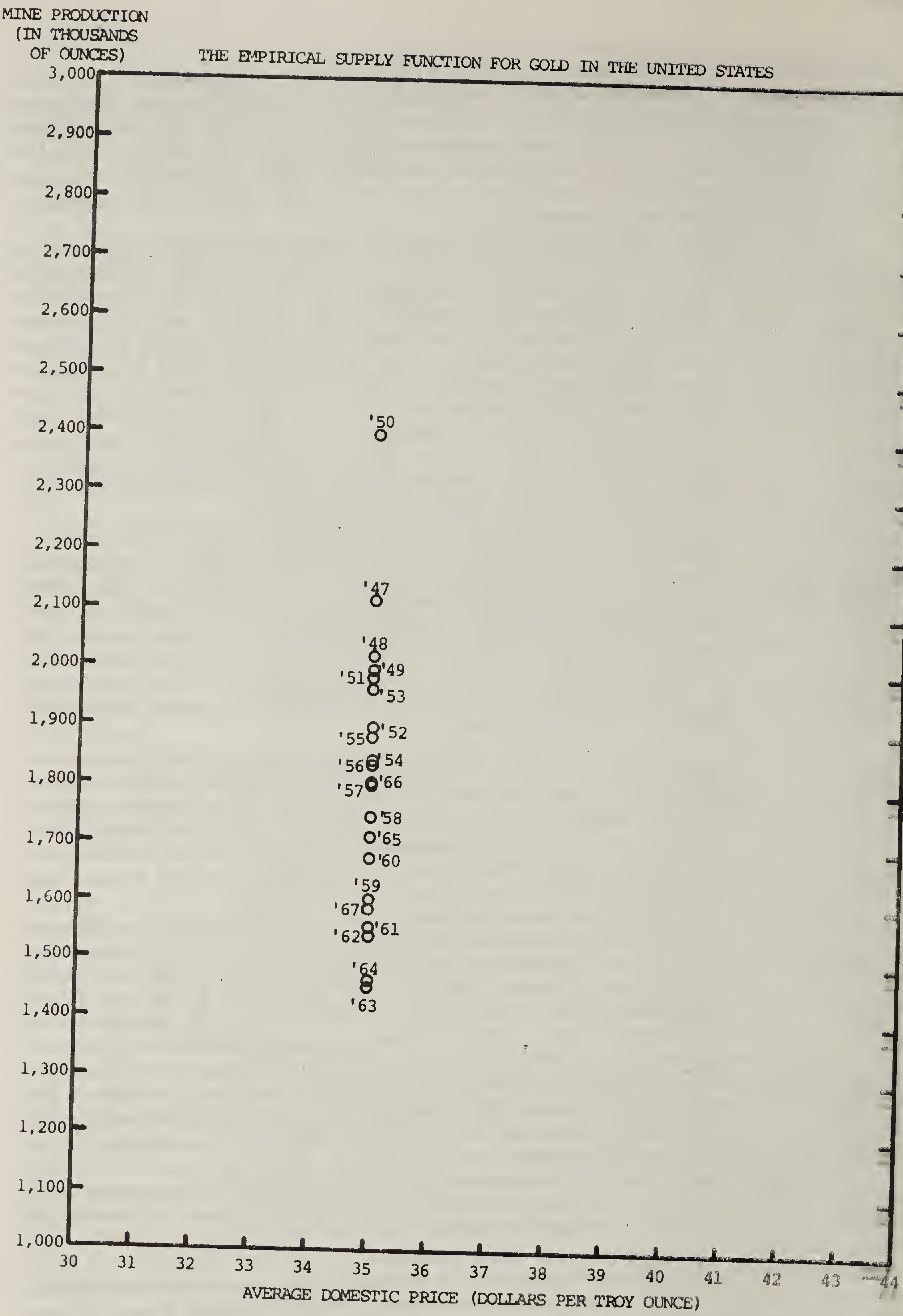


Fig. 1 - The Empirical Supply Function for Gold Production in the United States, 1947-1967.

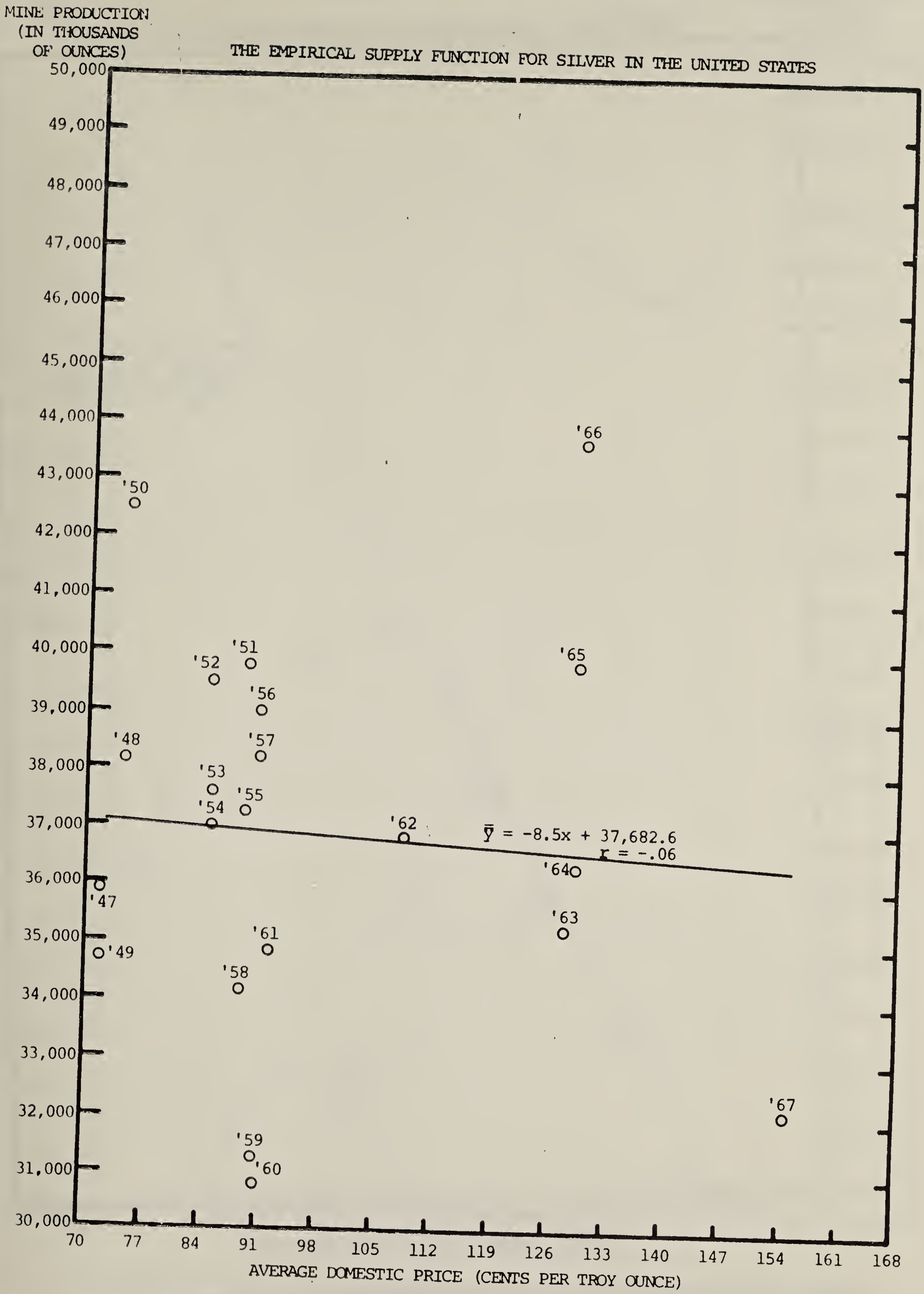


Fig. 2 - The Empirical Supply Function for Silver Produced in the United States, 1947-1967.

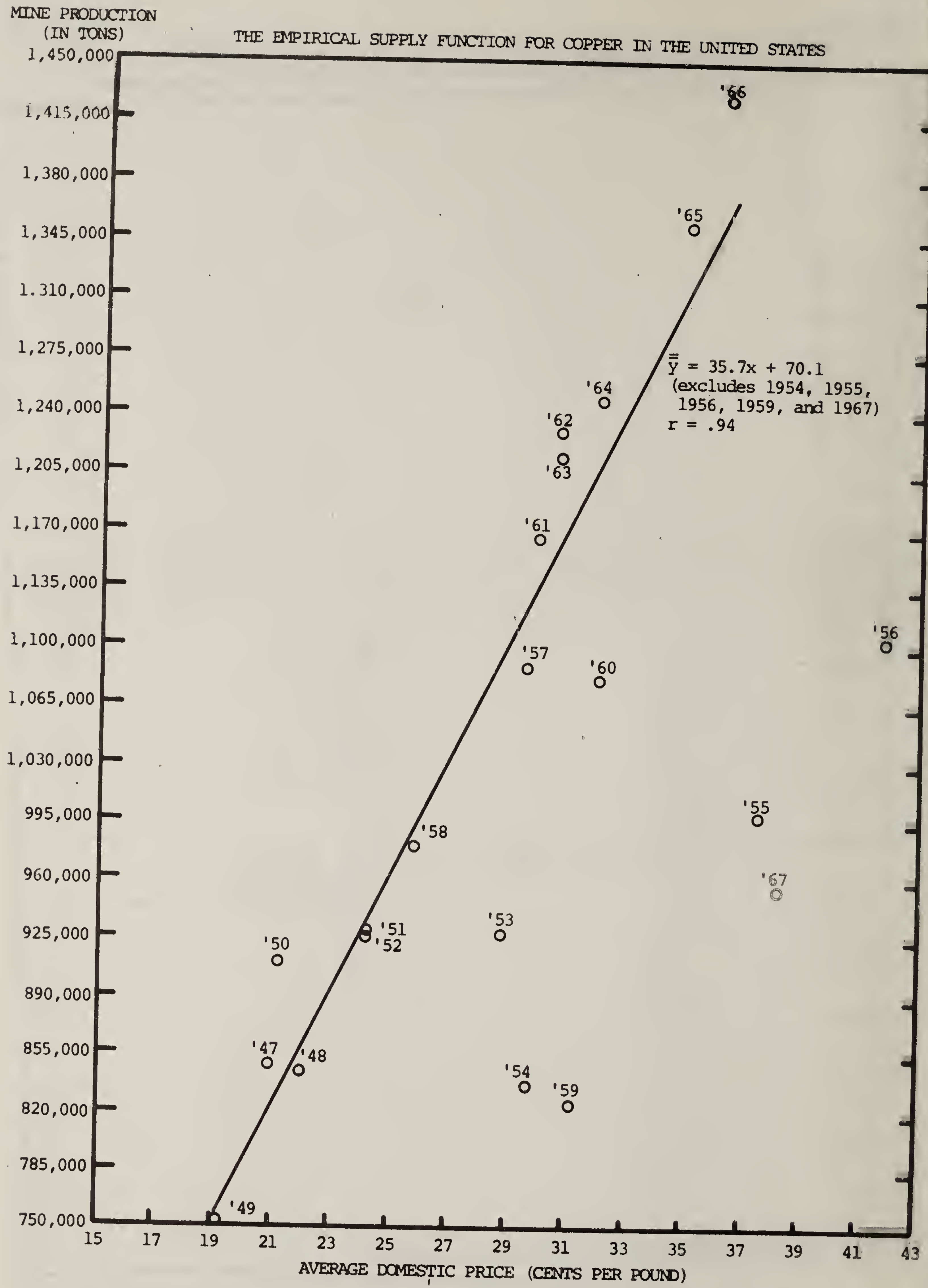
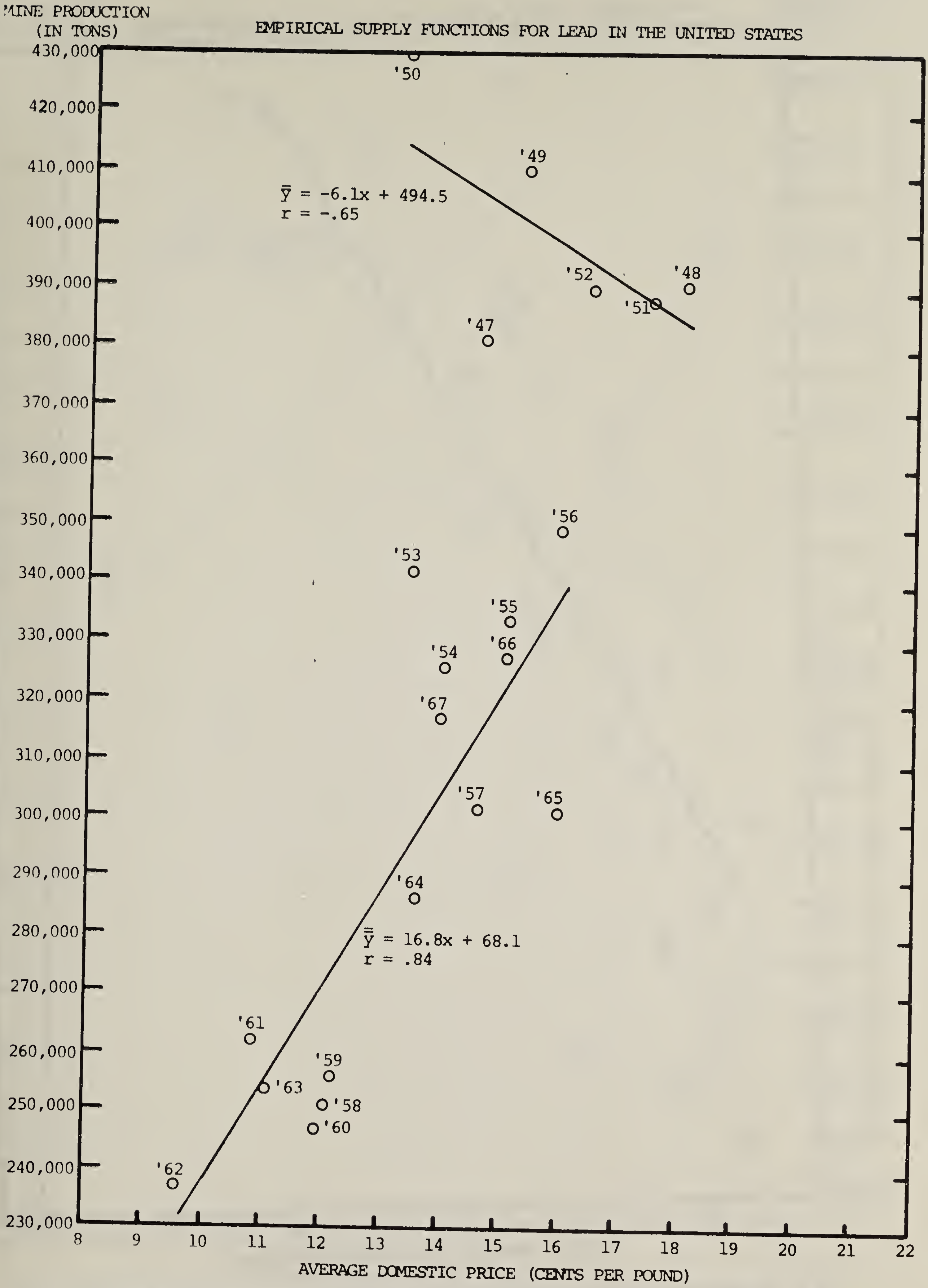


Fig. 3 - The Empirical Supply Function for Copper Produced in the United States, 1947-1967.



$\bar{\bar{y}} = -6.1x + 494.5$
$r = -.65$

$\bar{\bar{y}} = 16.8x + 68.1$
$r = .84$

Fig. 4 - Relatively Short Run Empirical Supply Functions for Lead Produced in the United States, 1947-1952 and 1953-1967.

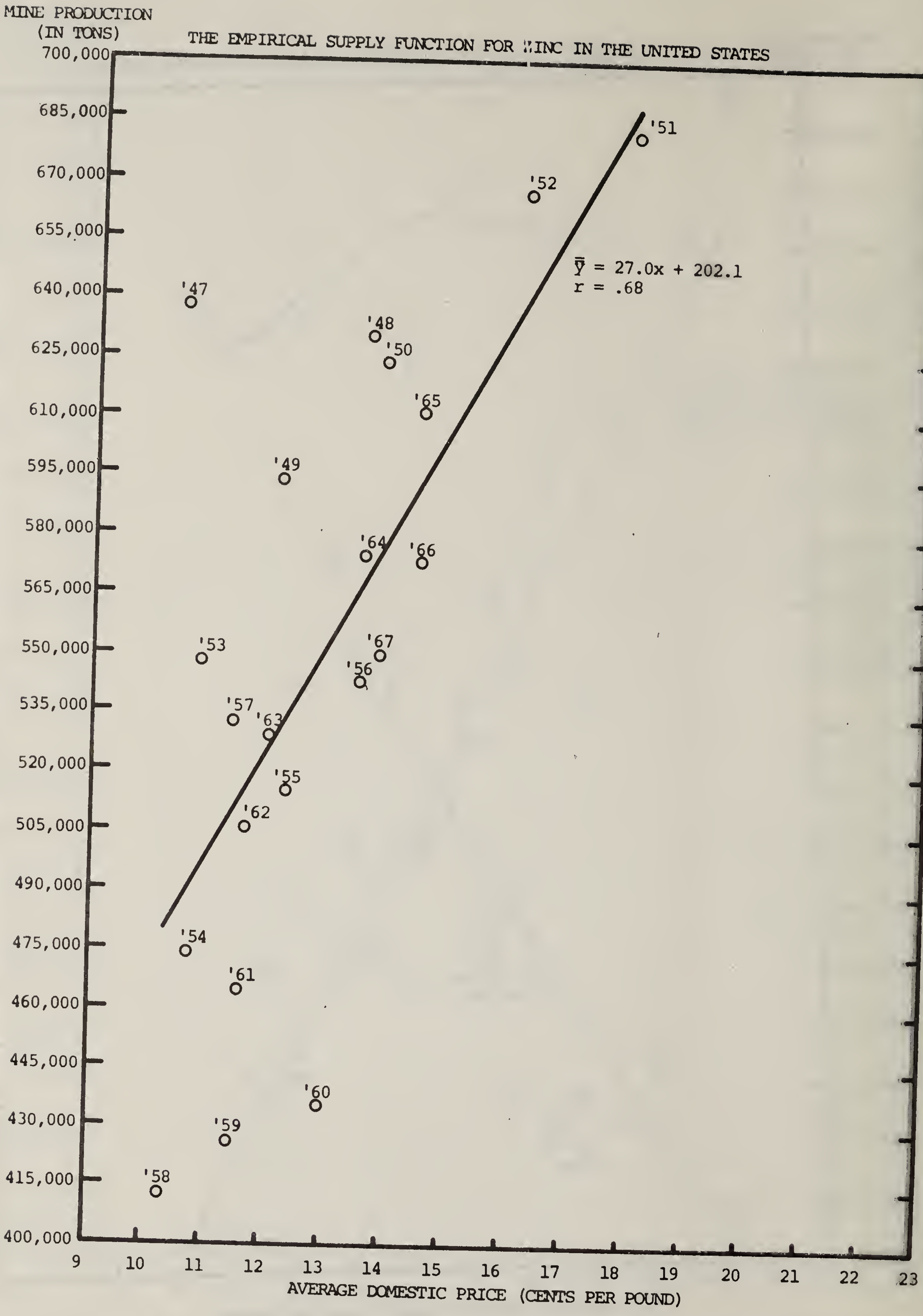


Fig. 5 - The Empirical Supply Function for Zinc Produced in the United States, 1947-1967.

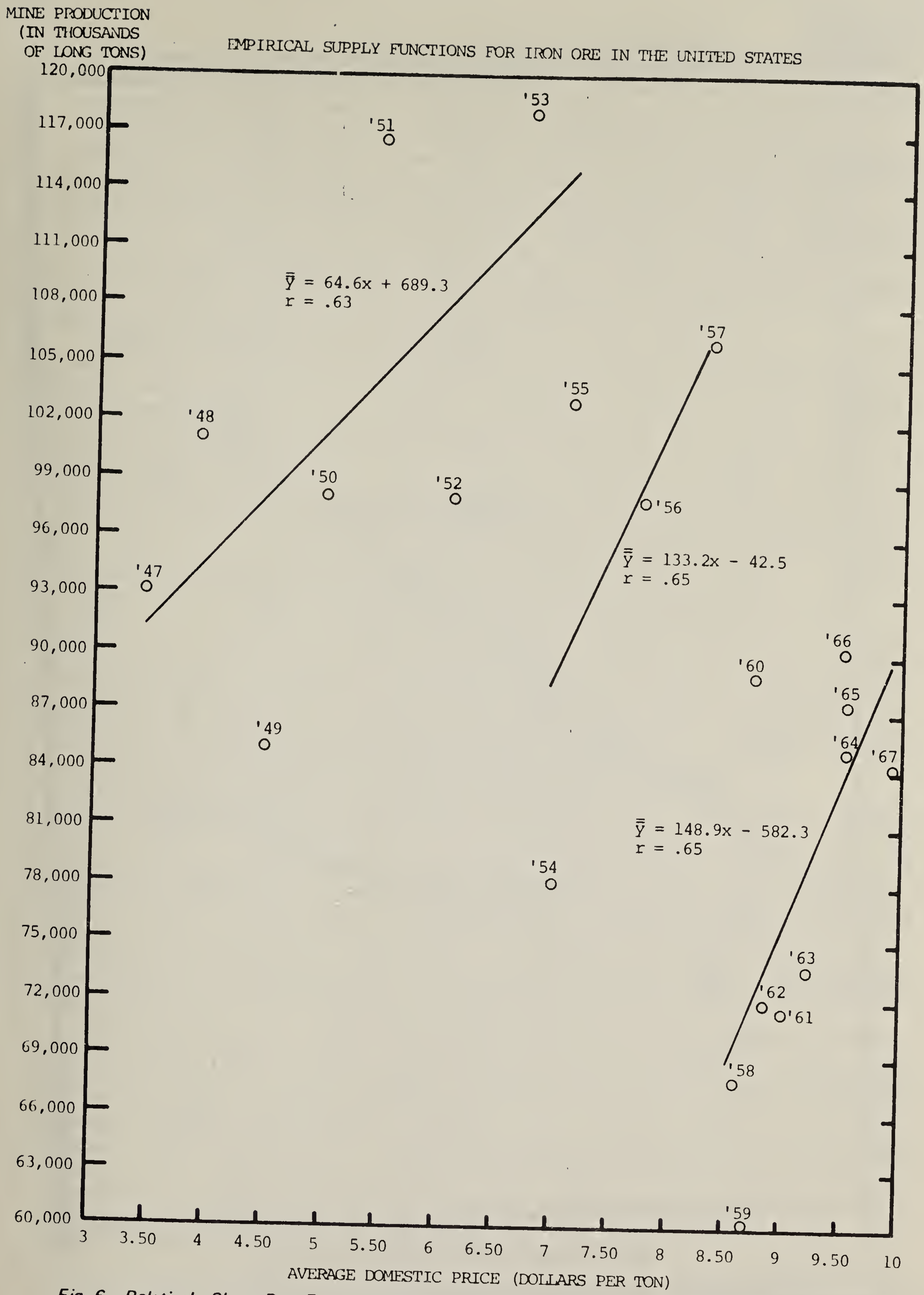


Fig. 6 - Relatively Short Run Empirical Supply Functions for Iron Ore Produced in the United States, 1947-1953, 1952-1957, and 1958-1967.

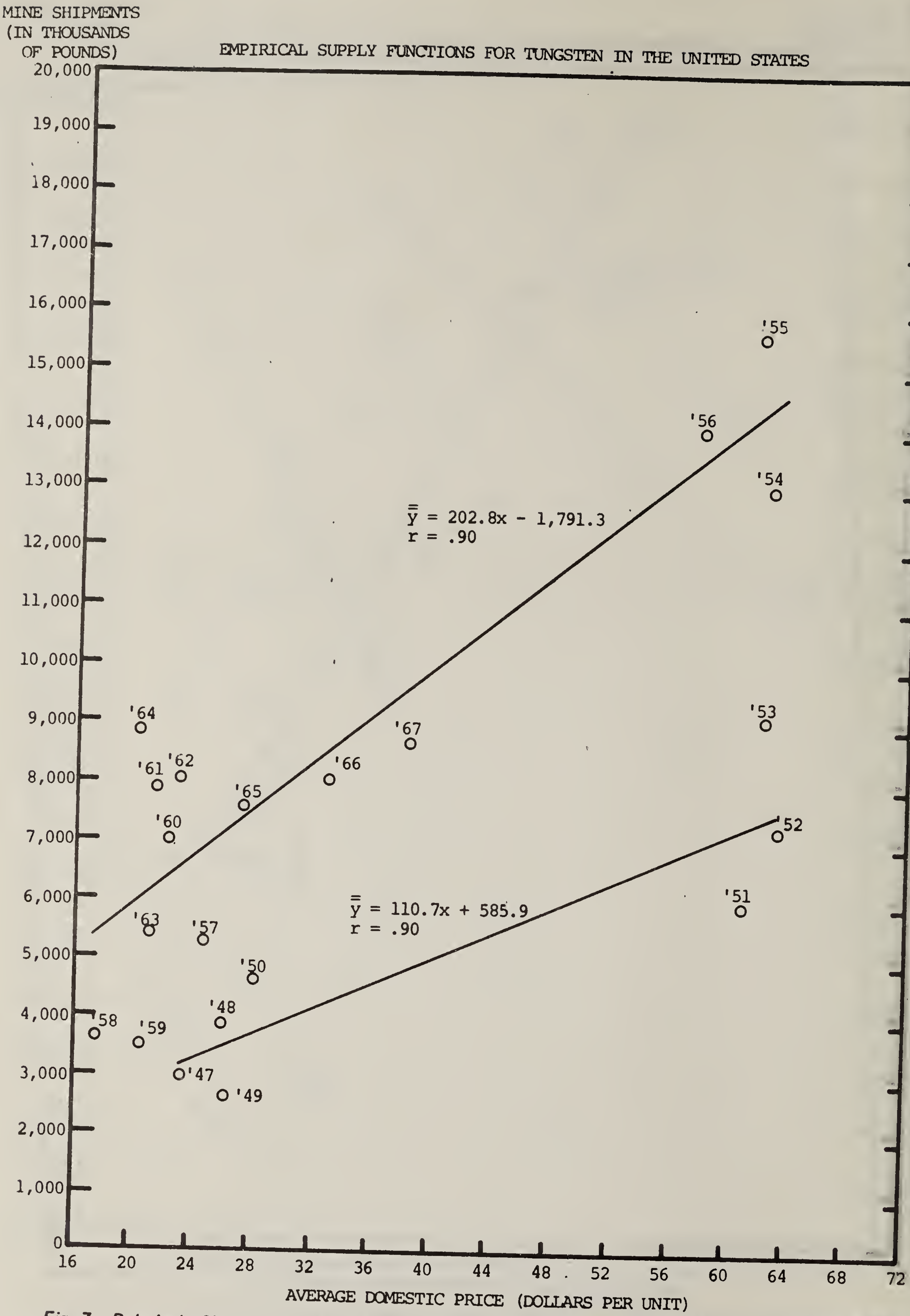


Fig. 7 - Relatively Short Run Empirical Supply Functions for Tungsten Produced in the United States, 1947-1953 and 1954-1967.

relationship maintained, but at a generally higher level of prices. The long-term relationship, however, has involved a decline in average domestic output as prices have risen, reflecting the importance of factors other than price in determining iron ore production.

The empirical supply functions indicating the responsiveness of domestic output to domestic prices for most of the ferrous additive metals have also shifted during the period since the end of World War II. From 1947 to 1953, the empirical supply function for tungsten exhibited a strong positive relationship between price and output, with about 80 percent of the changes in output associated with domestic price changes. From 1951 to 1955, however, there was a sharp upward shift in output with no corresponding change in price. Nevertheless, changing prices after 1955 were accompanied by changes in output similar to those experienced from 1947 to 1953 but at a higher minimum level of production, with a similar relationship extending from 1954 through to 1967.

Despite molybdenum's close association in use with iron and steel, its output responsiveness to changes in average domestic prices has more closely followed that of copper, with which it is more closely associated in production. From 1947-1967, approximately 72 percent of the variation in molybdenum output in the United States was directly associated with changes in the average domestic price. This has been a consistent relationship maintained over the full two decades. The supply function for nickel in the United States, although it has come from both primary and by-product sources, has followed a similar pattern. There was a dramatic rise in minimum domestic production levels after 1954 with the opening of the nation's principal nickel producer in Western Oregon. Since 1957, however (as shown by Figure 9), the annual output of nickel in the United States has been generally less responsive to price changes than over the long run.

Like that of tungsten, the empirical supply function termined for beryllium from 1947 to 1967 has shifted. The shift came at the beginning of the Korean War, however, for beryllium. Nevertheless, since 1953, there has been a consistent relationship established between the output of beryllium in the United States and the average domestic price. From 1947-1950, approximately 90 percent of the variation of domestic output was directly associated with changes in the average domestic price. Since 1953, the closeness of the relationship has diminished somewhat so that about 75 percent of the variation in domestic output was directly associated with variation in the average domestic price.

The annual production of mercury in the United States has shown only a very slight positive relationship with the fluid metal's average domestic price. From 1947-1967 (as shown by Figure 11), only four percent of the year-to-year variation in domestic output was directly associated with changes in the average domestic price. With the technical circumstances involved in the exploration for development of and production from mercury deposits, however, a much closer relationship would be established on a time lag basis. The lack of a strong relationship on an annual basis indicates forcefully that the time involved in responding to price changes is more than one year for mercury. Even with such a lag, however, there are indications that the average domestic price of mercury is a result rather than a cause of the amount of mercury produced in the United States.

Like a number of the other minor metals, uranium has had a varied history in the response of its domestic output to domestic prices. From 1957-1963, the relationship between the domestic output of uranium and domestic price was a very strong negative one. During this period, approximately 90 percent of the variation in domestic output was inversely associated with variation in domestic price. In other words, as domestic price declined from 1957 through 1961, production increased (or as production increased, prices declined). After 1963, however, a more positive relationship was established more in keeping with the normal associations between the outputs of other mineral commodities and their prices. For the period from 1963 through 1967, approximately 45 percent of the variation in domestic output of uranium was directly associated with the average domestic price of the nuclear metal.

Lke the metals, many of the nation's industrial minerals have exhibited wide variations in their responses of production to changes in domestic prices. Phosphate rock has

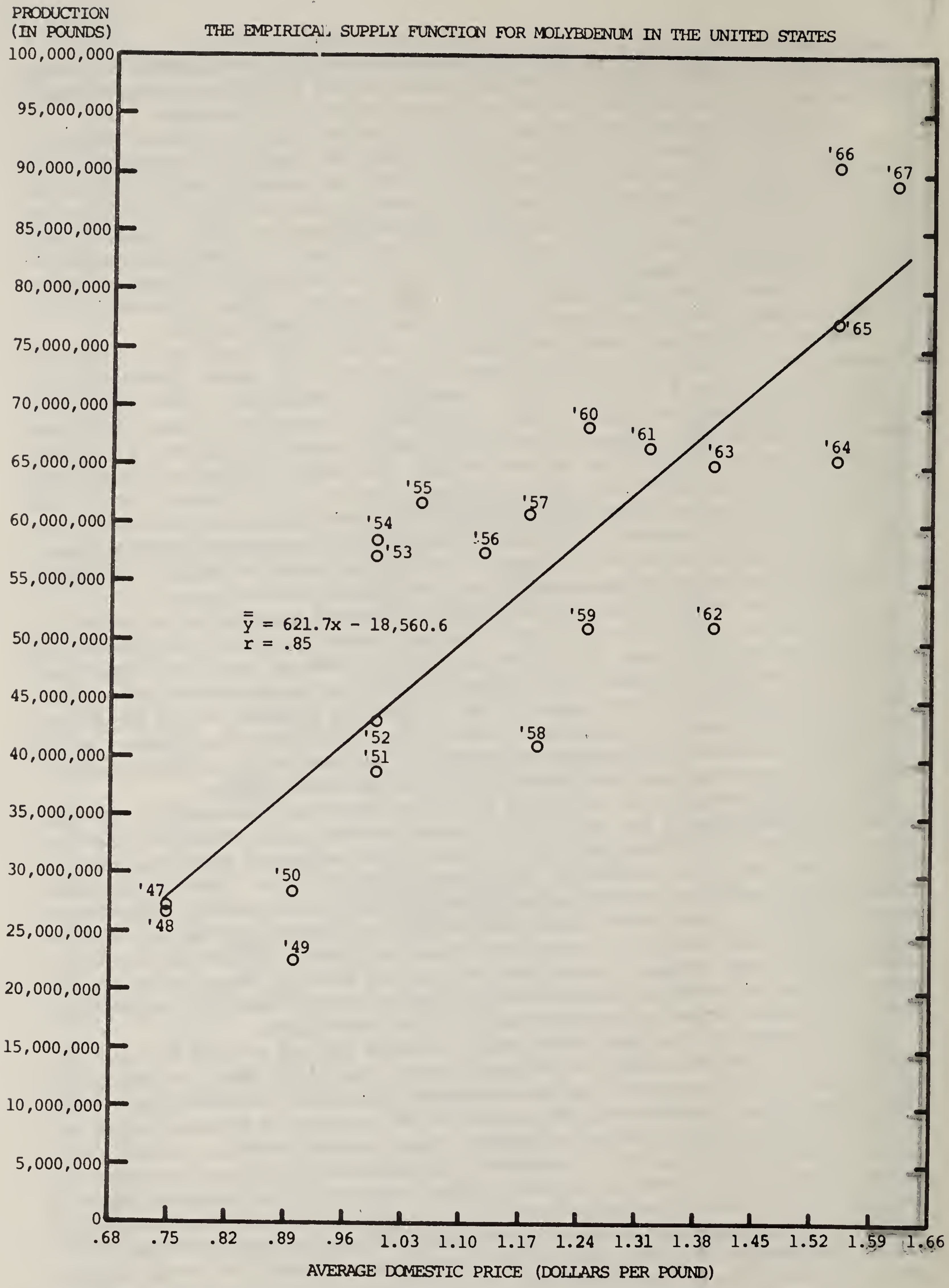


Fig. 8 - The Empirical Supply Function for Molybdenum Produced in the United States, 1947-1967.

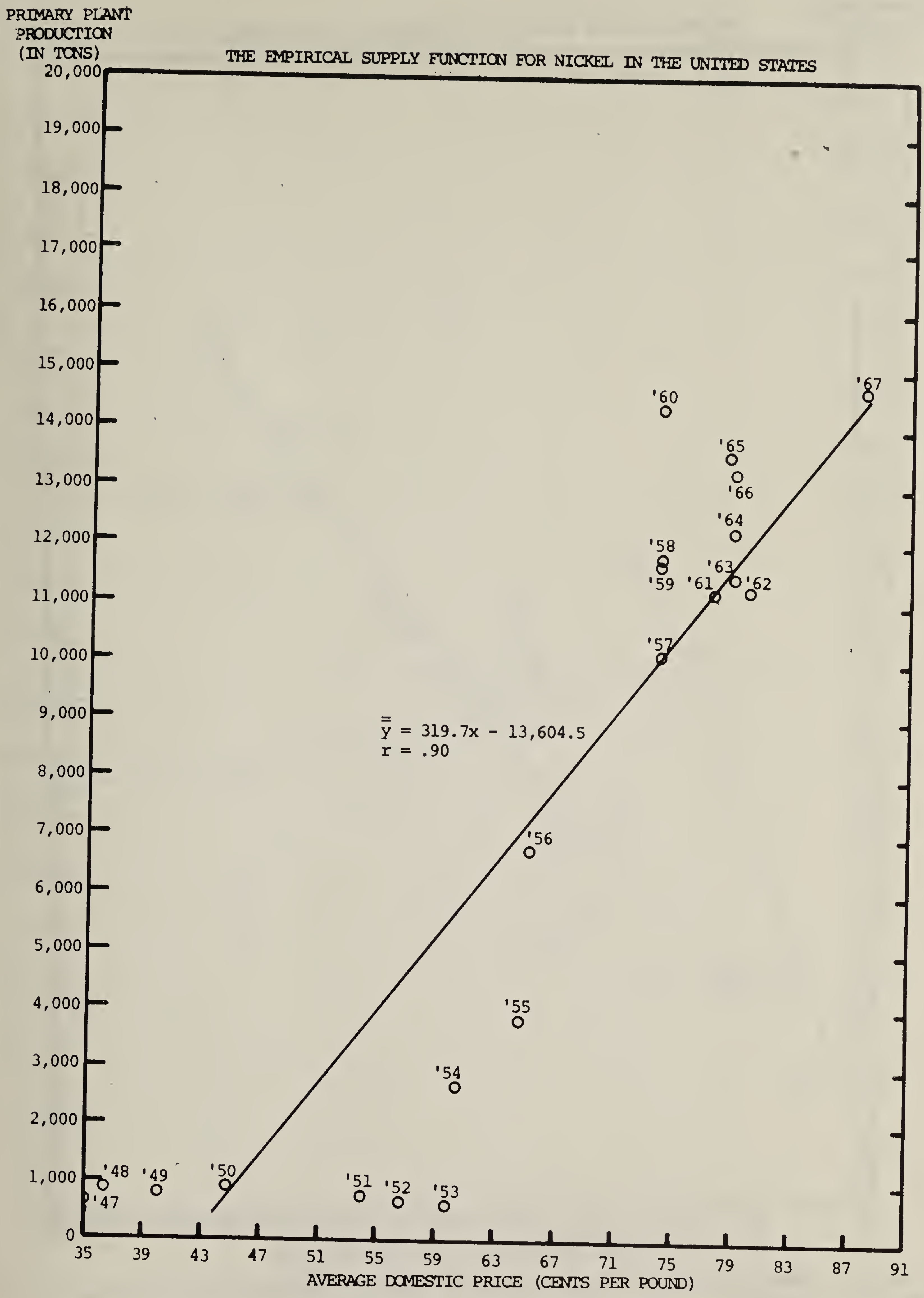


Fig. 9 - The Empirical Supply Function for Nickel Produced in the United States, 1947-1967.

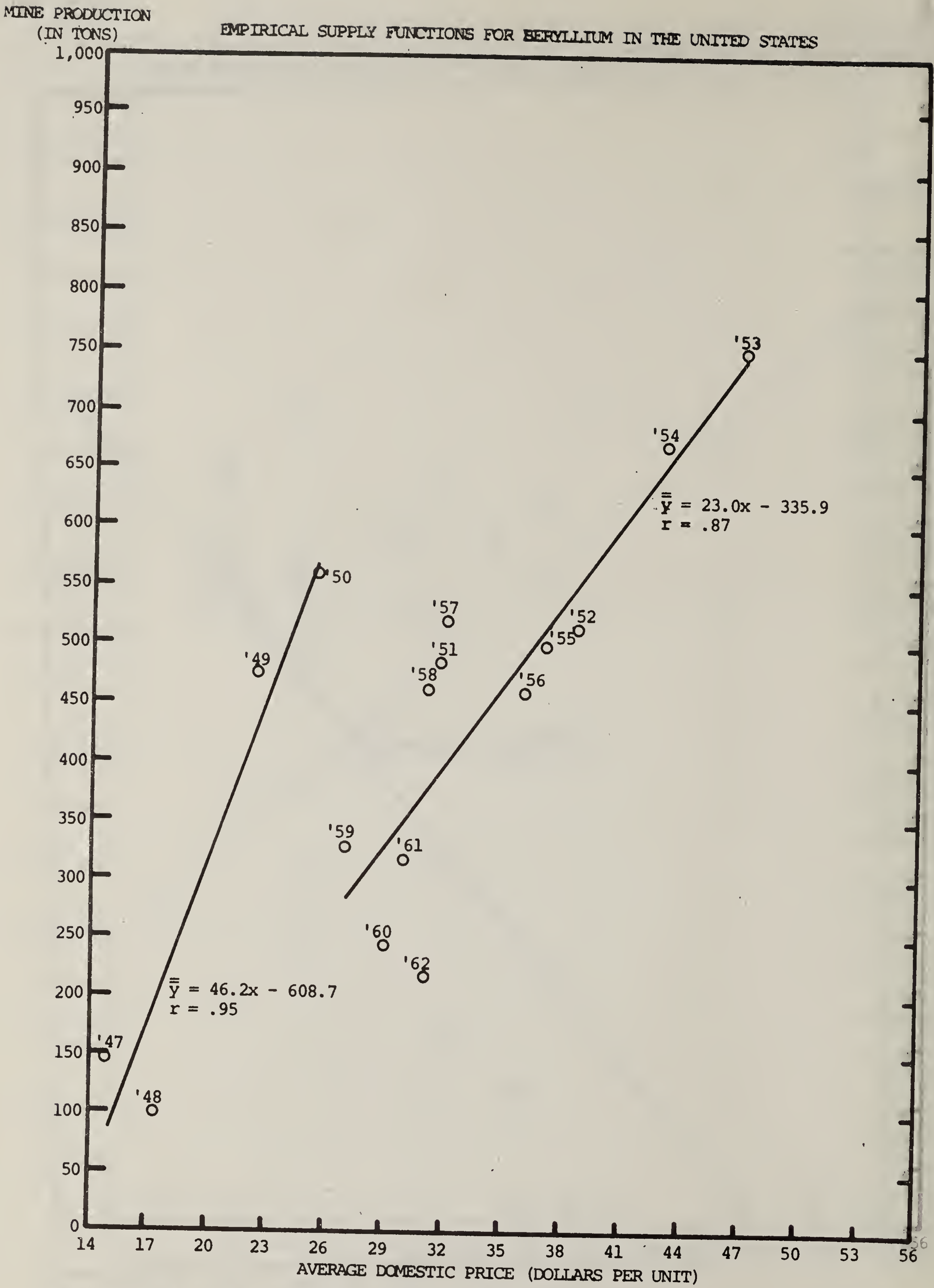


Fig. 10 - Relatively Short Run Supply Functions for Beryllium Produced in the United States, 1947-1950 and 1951-1967.

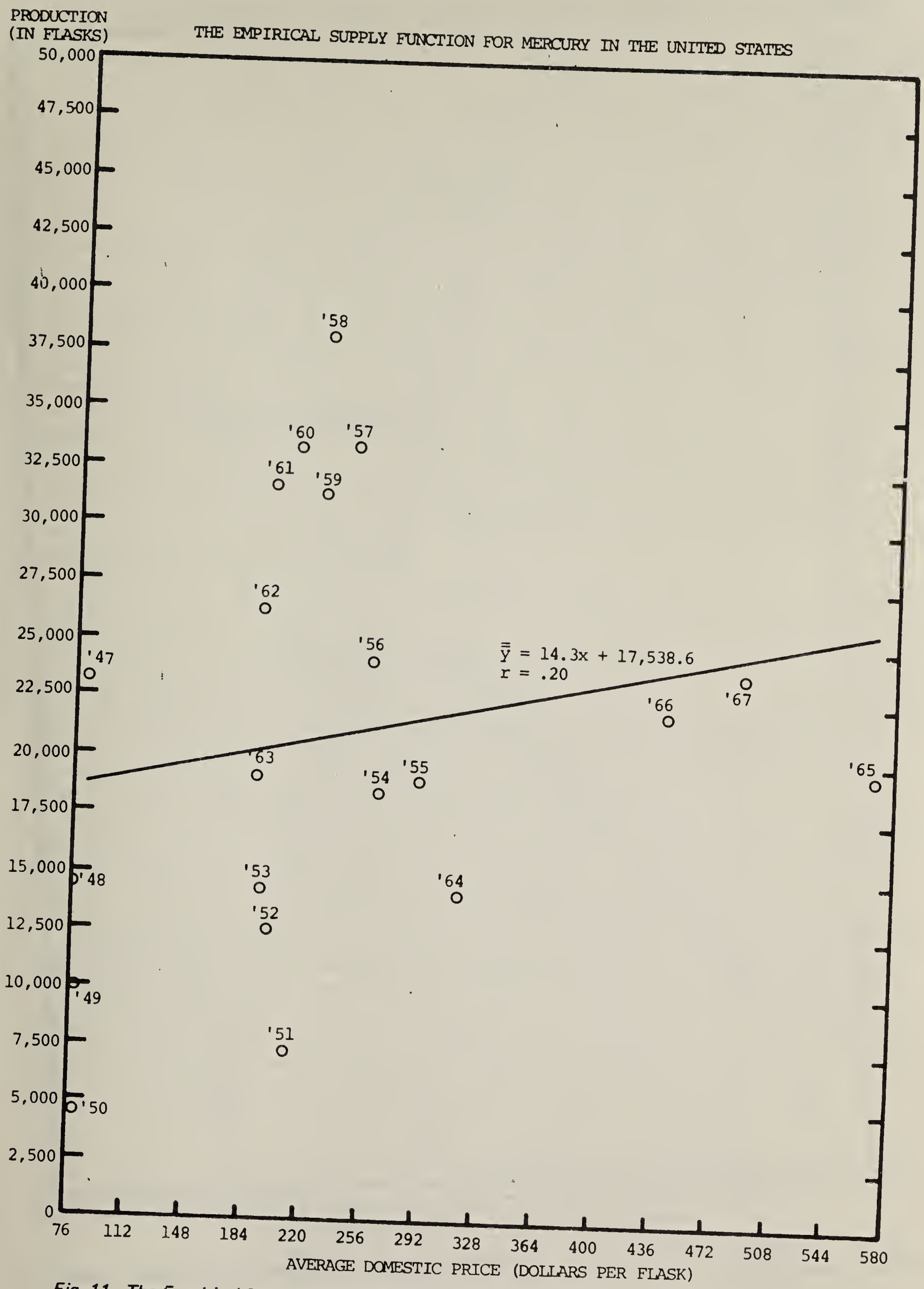


Fig. 11 - The Empirical Supply Function for Mercury Produced in the United States, 1947-1967.

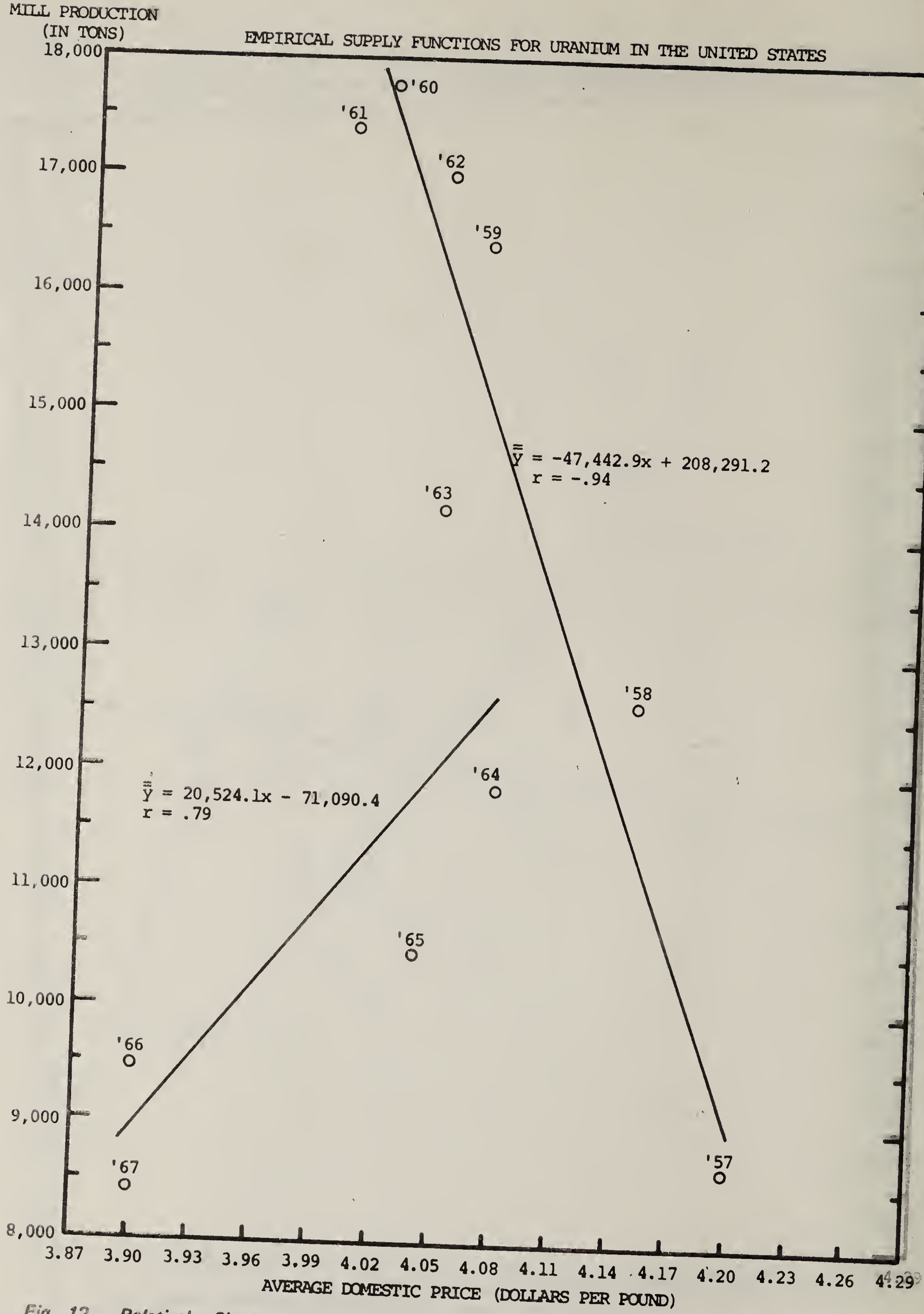


Fig. 12 - Relatively Short Run Supply Functions for Uranium Produced in the United States, 1957-1963 and 1963-1967.

demonstrated one of the closest relationships. For the period from 1947 through 1967, approximately 90 percent of the variation in the domestic output of phosphate rock was directly associated with variation in the average domestic price. This was not true, however, for the other major fertilizer mineral, potash. Quite the contrary, although exhibiting a general upward shift of production levels in response to price increases over the long term from 1947 to 1967, the short-term supply function for potash (as shown in Figure 14) has exhibited a negative characteristic. For the entire period from 1947 to 1967, the long run response of potash supply has been positive, however, with about 45 percent of the variation in output directly associated with changes in the average domestic price. Nevertheless, there have been three definite short run periods, in which the responsiveness of potash supply to domestic price has been negative, with output increasing as prices declined. In 1947, 1948, and 1949, the relationship was virtually perfect with increases in price being accompanied by corresponding decreases in annual output (or vice versa). For the period from 1954 through 1960 (after the Korean War and before the start of the Viet Nam War), a similar relationship existed although it was not quite as strong. During these years, approximately 63 percent of the variation in potash output in the United States was negatively associated with changes in domestic price, with increases in price being accompanied by decreases in output. Since 1960, the relationship between potash price and output in the United States has deteriorated substantially, although there have been indications since 1961 that another inverse relationship is forming at a still higher level of output and somewhat higher level of price than previously. Since 1961, only 20 percent of the variation in domestic potash output has beer associated with variation in the average domestic price for the fertilizer mineral.

Limestone has shown itself to be particularly sensitive to prices in two of its major markets, as shown by Figures 15 and 16. From 1947 to 1967, more than 80 percent of the variation in limestone and dolomite production in the United States was directly associated with changes in the average domestic price for *lime*. For the period from 1947 to 1960, an even stronger positive relationship was established between domestic limestone and dolomite production and the price of *cement*. Since 1960, however, there has been an almost equally strong inverse relationship between domestic limestone production and cement prices. From 1947-1960, more than 95 percent of the variation in the nation's annual output of limestone and dolomite was directly associated with changes in the average price of cement. From 1961 to 1967, on the other hand, 90 percent of the yearly variation in limestone and dolomite production in the United States has been *negatively* associated with changes in the average domestic price of cement. Since the early 1960's, limestone and dolomite output in the states has increased sharply despite the fact that cement prices have declined. It may also be that cement prices have declined because output has increased, but the price decline is probably the result of the slump in construction during the early 1960's.

The responsiveness of asbestos production in the United States to average asbestos prices has likewise shown a split relationship but for different periods of time. From 1947 through 1963, the production of asbestos in the United States was at a relatively low level but was directly associated with the average domestic price of the mineral fiber. The relationship was not close, however, with only about 11 percent of the changes in domestic output directly associated with price changes. Beginning in 1964, and extending through 1967, a much closer relationship was established between domestic asbestos output and prices at a much higher level of output. From 1964 through 1967, approximately 90 percent of the annual variation in the nation's output of asbestos was directly associated with changes in the average domestic price. This dramatic shift in the supply function of asbestos in the United States typifies the normal long run supply responsiveness of mineral exploration and development to increasing prices. The diagram in Figure 17 is graphic evidence of this. As domestic prices for asbestos increased from 1947 through 1958, exploration activity for the mineral fiber increased. Discovery of deposits in the early 1960's and their subsequent development in the following years brought a reduction in domestic price accompanied by relatively large increases in the supply of the mineral fiber available. Since that time, with

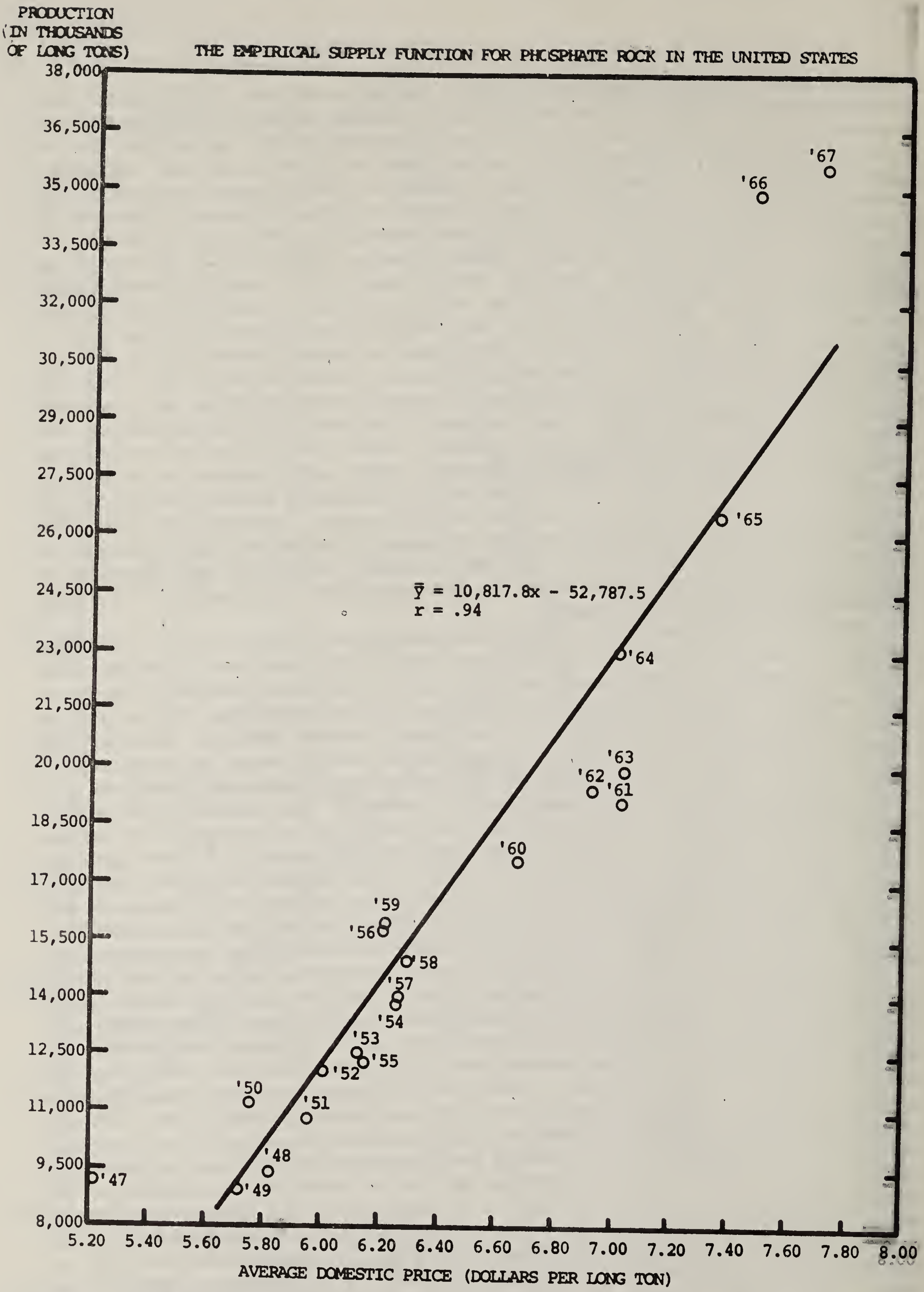


Fig. 13 - The Empirical Supply Function for Phosphate Rock Produced in the United States, 1947-1967.

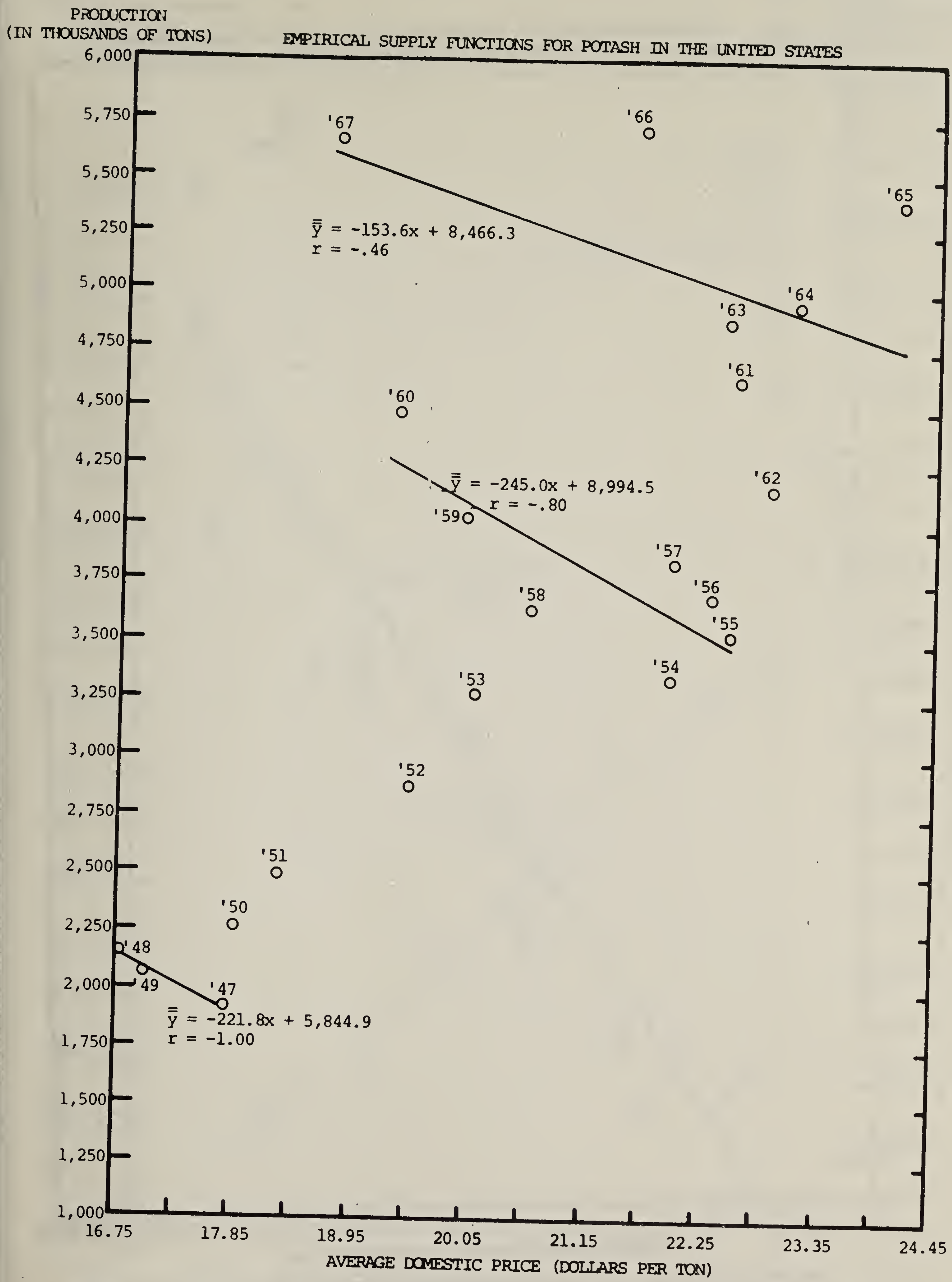


Fig. 14 - Relatively Short Run Supply Functions for Potash Produced in the United States, 1947-1949, 1954-1960, and 1961-1967.

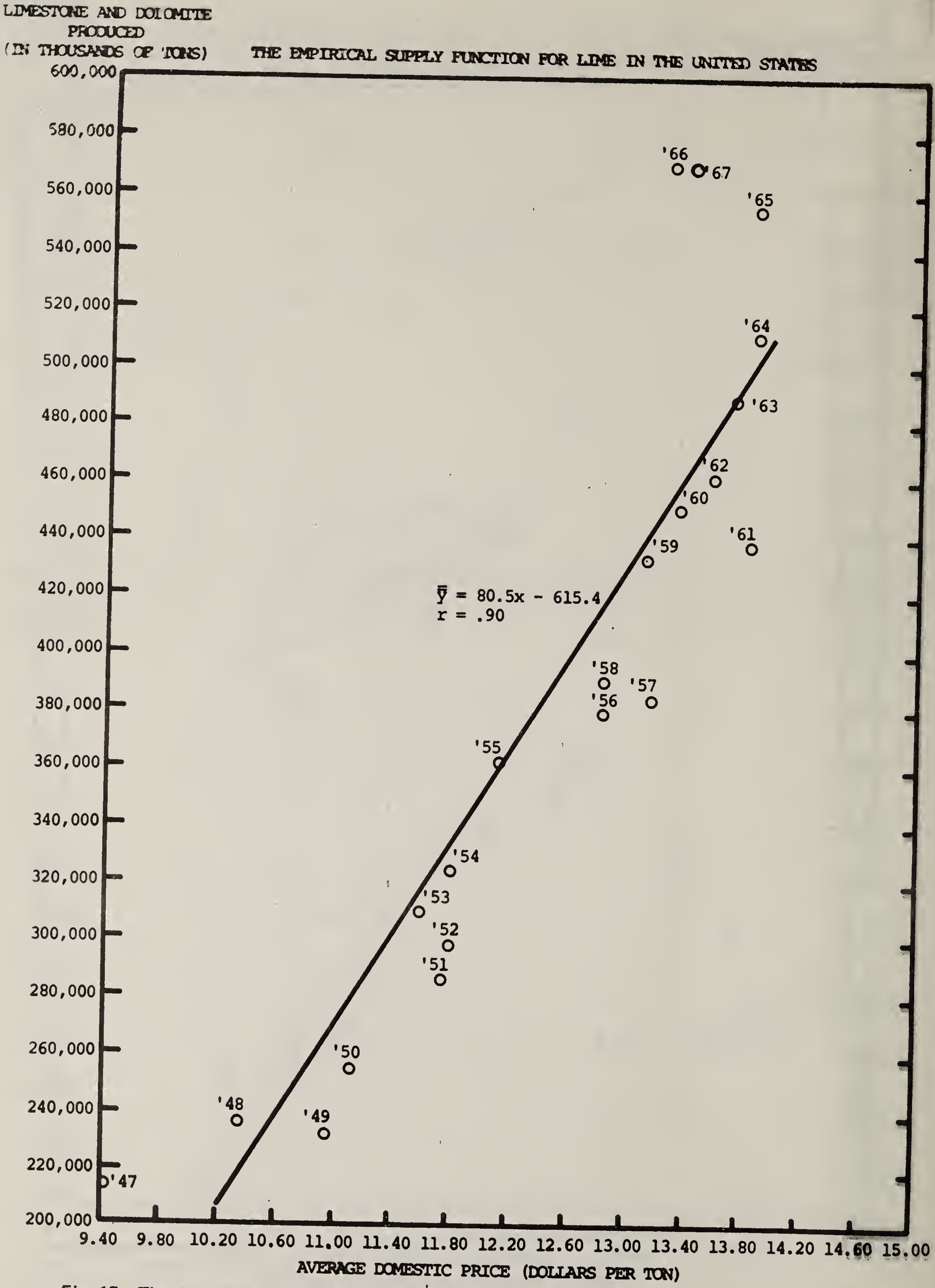


Fig. 15 - The Relationship Between the Average Price of Lime in the United States and Total Domestic Limestone and Dolomite Production.

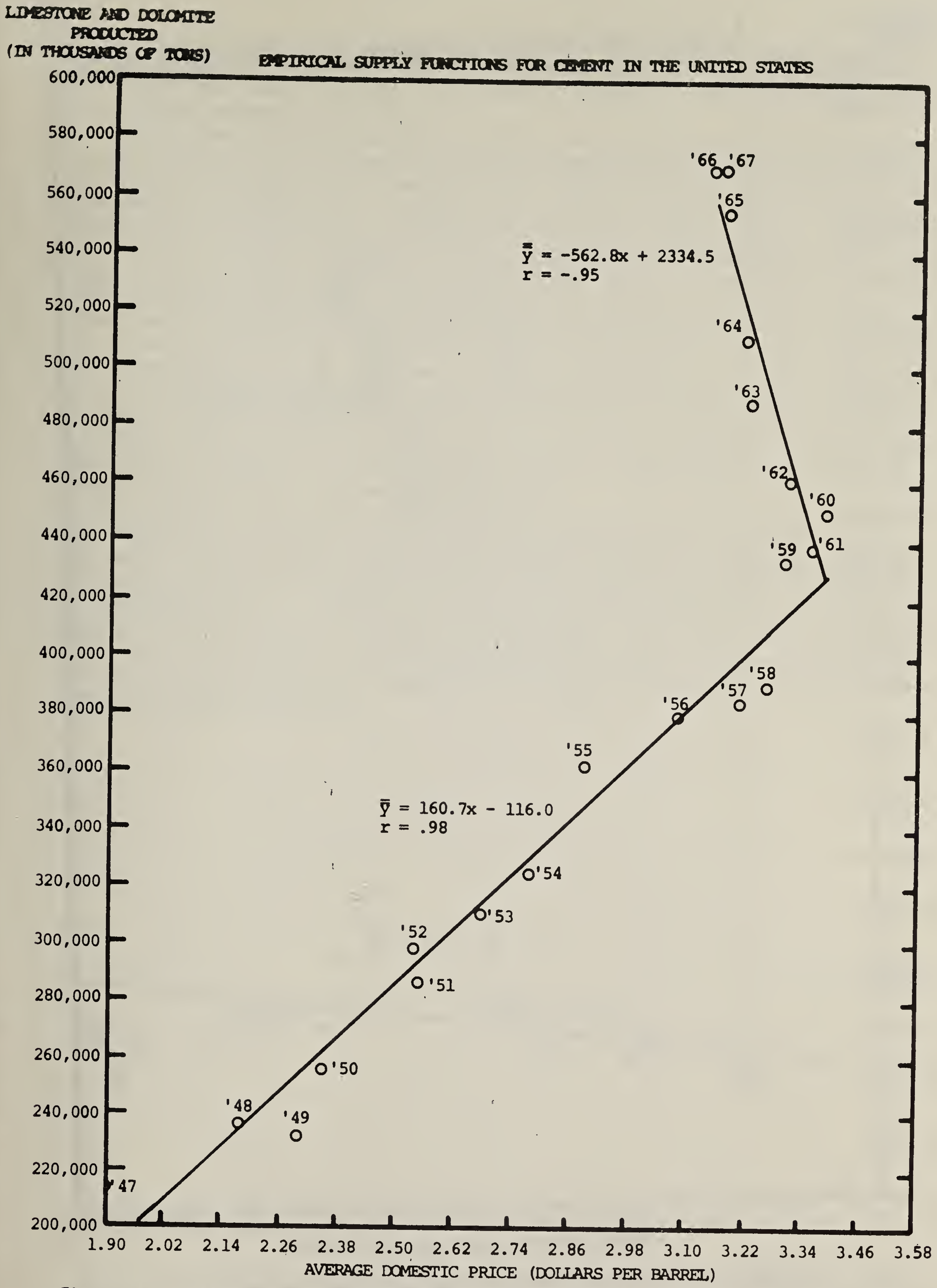


Fig. 16 - The Relatively Short Run Relationships Between the Average Price of Cement in the United States and Total Domestic Limestone and Dolomite Production.

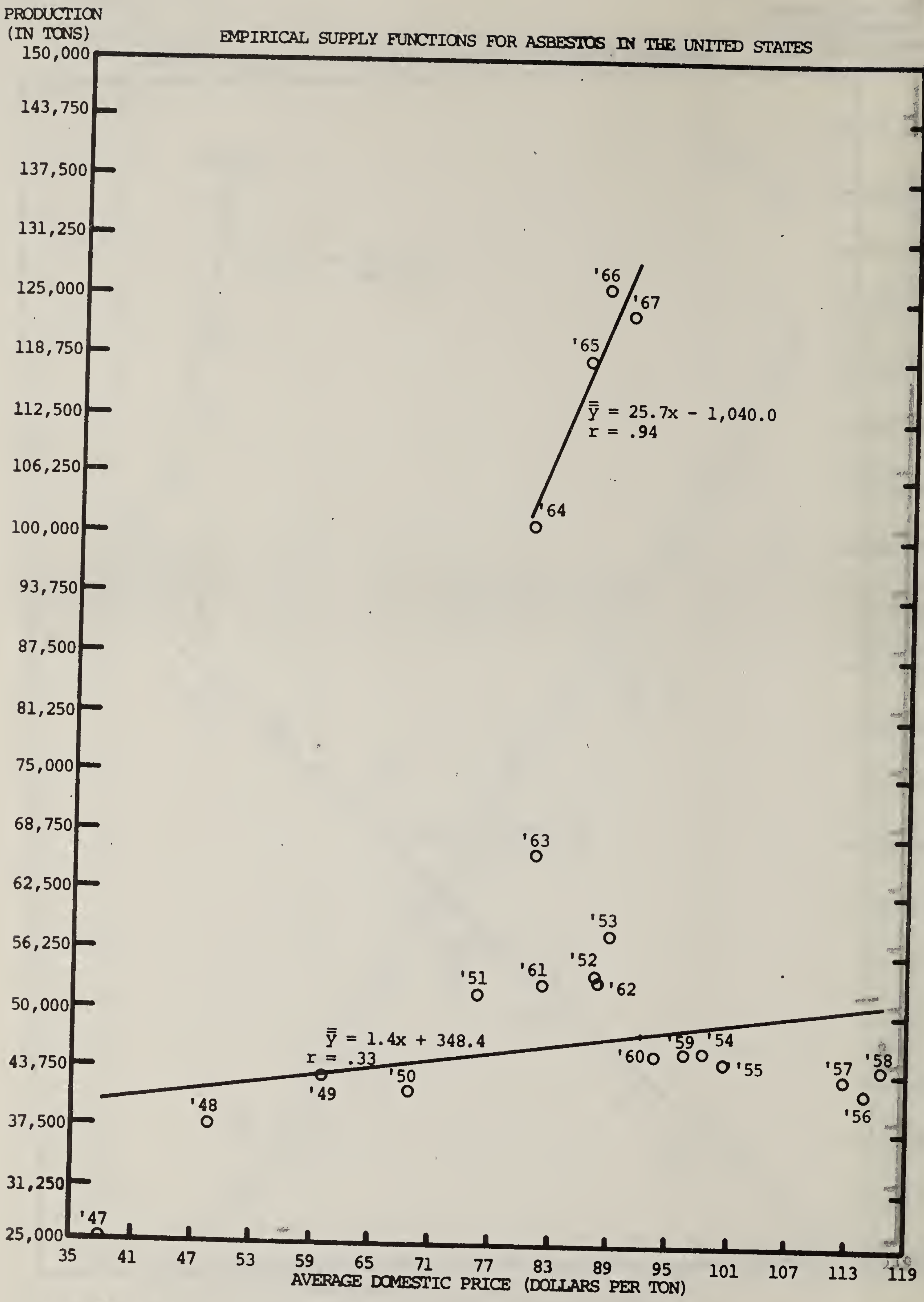


Fig. 17 - Relatively Short Run Empirical Supply Functions for Asbestos Produced in the United States, 1947-1963 and 1964-1967.

domestic production in the hands of a relatively small number of producers, output and prices have kept closely in line with moderate increases in prices accompanied by corresponding increases in production.

Sodium mineral production in the United States has been much less responsive to either long run or short run price changes than have other industrial minerals. From 1947 to 1967, the empirical supply functions for sodium carbonate produced in the United States showed a variable but generally direct relationship with changes in the average domestic price. Through 1956, the relationship was reasonably strong. Since 1956, however, a relatively constant price for sodium carbonate has been accompanied by wide variations in domestic output. The increased output that accompanied the slight increase in price in 1966, however, indicates that a shift in the empirical supply function to a higher base level of production may have taken place. A similar pattern for the period from 1947 to 1965 has held for sodium sulfate output, as shown in Figure 19. Since 1955, with the exception of 1958, there have been wide variations in sodium sulfate production despite a relatively constant domestic price. This is also true for sodium metal, as shown in Figure 20. Three long periods of price stability for sodium metal have been accompanied by wide variations in domestic output at each price level. Over the long run from 1951 to 1967, only about 16 percent of the variation in the nation's annual output of sodium metal has been directly associated with variation in its average domestic price.

Price sensitivities for mineral commodities produced in the United States have been quite variable over the last two decades and can be expected to remain so over the next two. The outputs of most mineral commodities are directly responsive to change in price, with higher prices resulting in increased production. Other factors, however, make the closeness of this relationship vary considerably from one commodity to another, and for some minerals such as mercury, it is not at all dependable. For a few minerals, negative output-price relationships have been established for short run periods of time. Nevertheless, even for these minerals, long run supply functions appear to be positive in nature, with supplies increasing as prices rise.

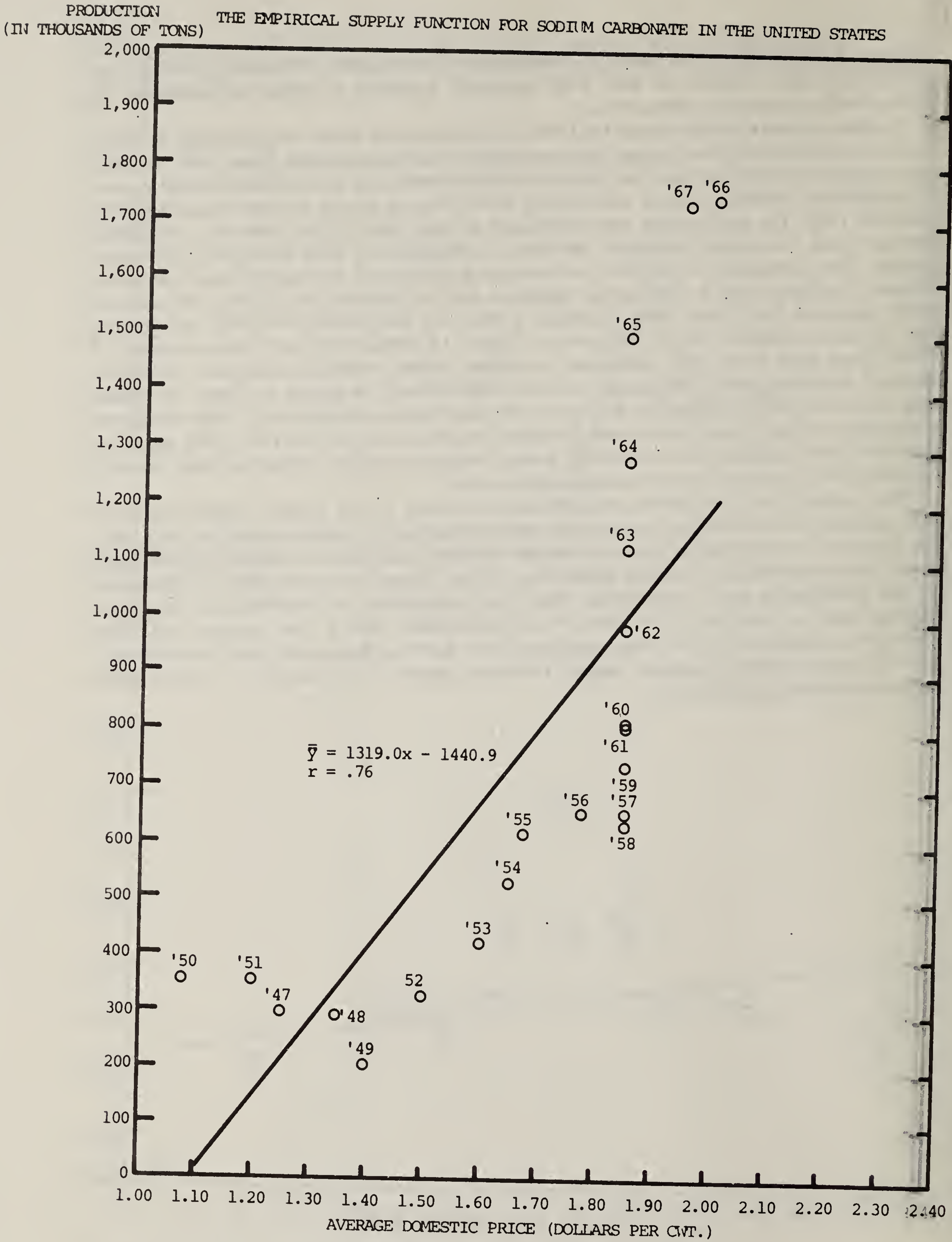


Fig. 18 - The Empirical Supply Function for Natural Sodium Carbonate Produced in the United States, 1947-1967.

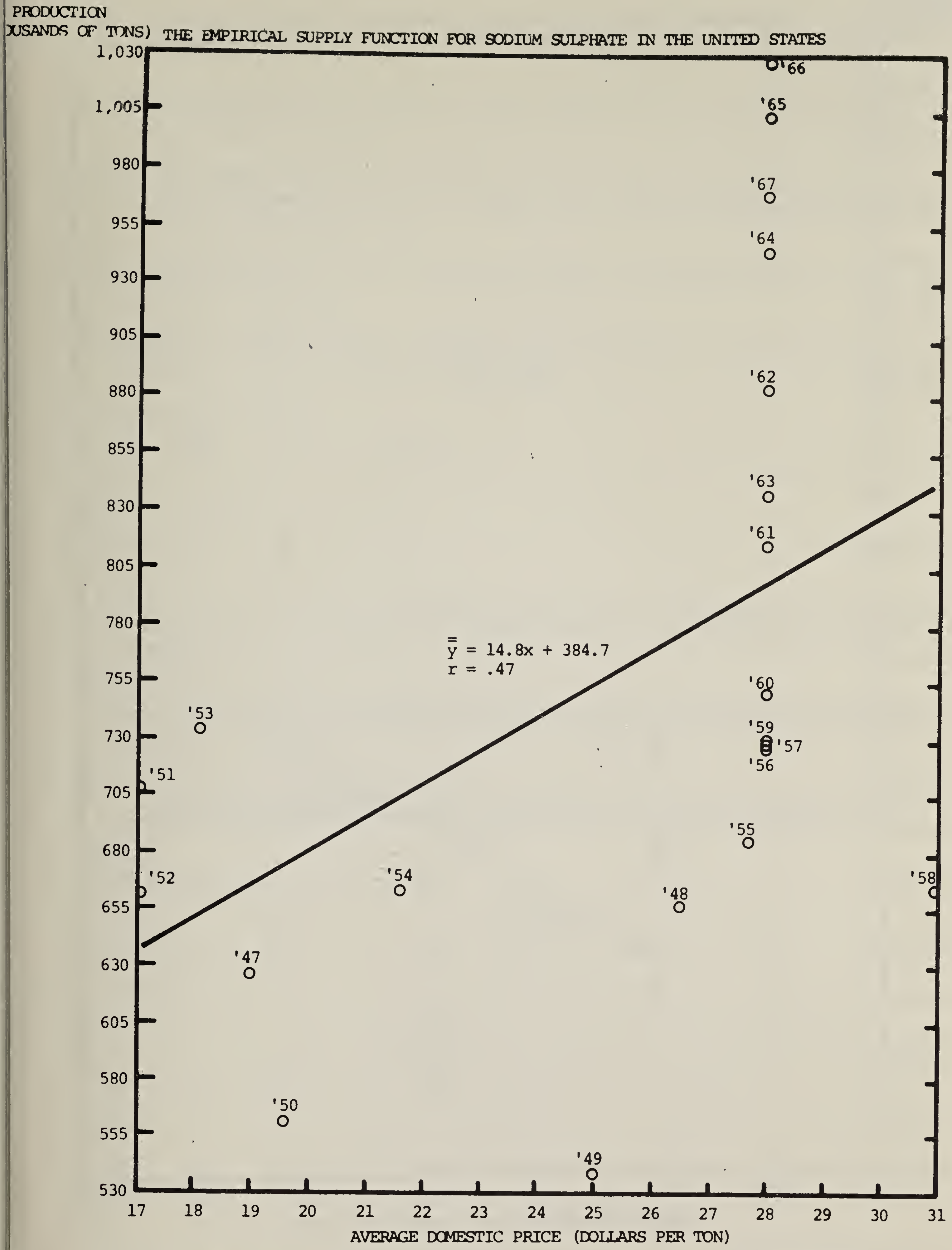


Fig. 19 - The Empirical Supply Function for Sodium Sulphate Produced in the United States, 1947-1967.

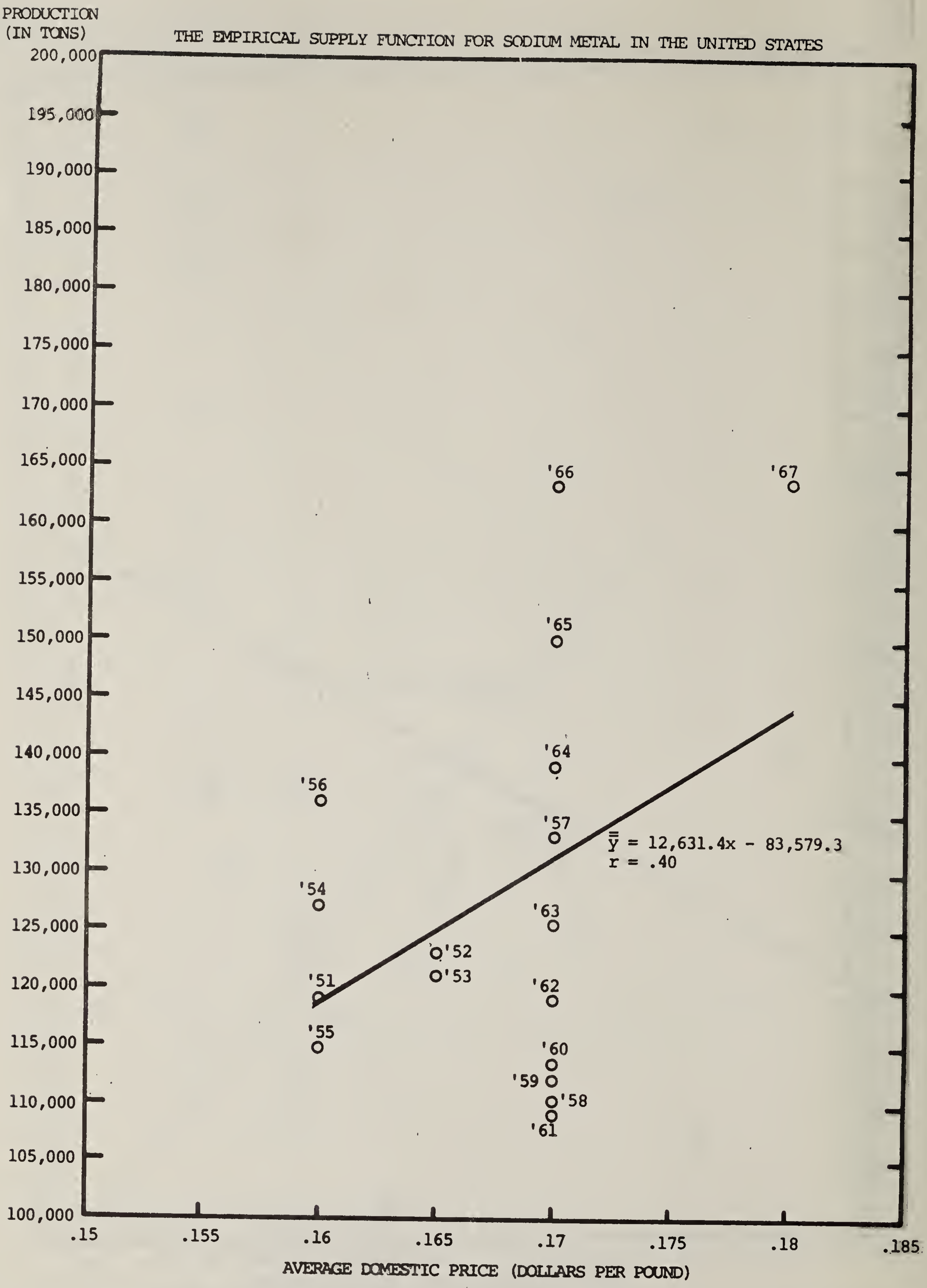


Fig. 20 - The Empirical Supply Function for Sodium Metal Produced in the United States, 1947-1967.

FOOTNOTES

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2/ J. D. DeBour, *The Industrial Resources of the Southern and Western States,* Vol. I (1852), pp. 253-254; and D. A. Wells, *Recent Economic Changes,* New York: D. Appleton and Company (1899).

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5/ *Ibid.,* pp. 101-102.

6/ D. A. Wells, *op. cit.,* pp. 136-137.

7/ T. A. Rickard, *op. cit.,* p. 110.

8/ D. A. Wells, *op. cit.,* pp. 134-136.

9/ S. D. Strauss, "Marketing of Nonferrous Metals and Ores," *Economics of the Mineral Industries,* New York: American Institute of Mining, Metallurgical, and Petroleum Engineers (1959), pp. 275-297.

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11/ F. G. Pardee, "Marketing of Iron Ore," *Economics of the Mineral Industries,* New York: American Institute of Mining, Metallurgical, and Petroleum Engineers (1959), p. 313.

12/ S. D. Strauss, *op. cit.,* pp. 281-297.

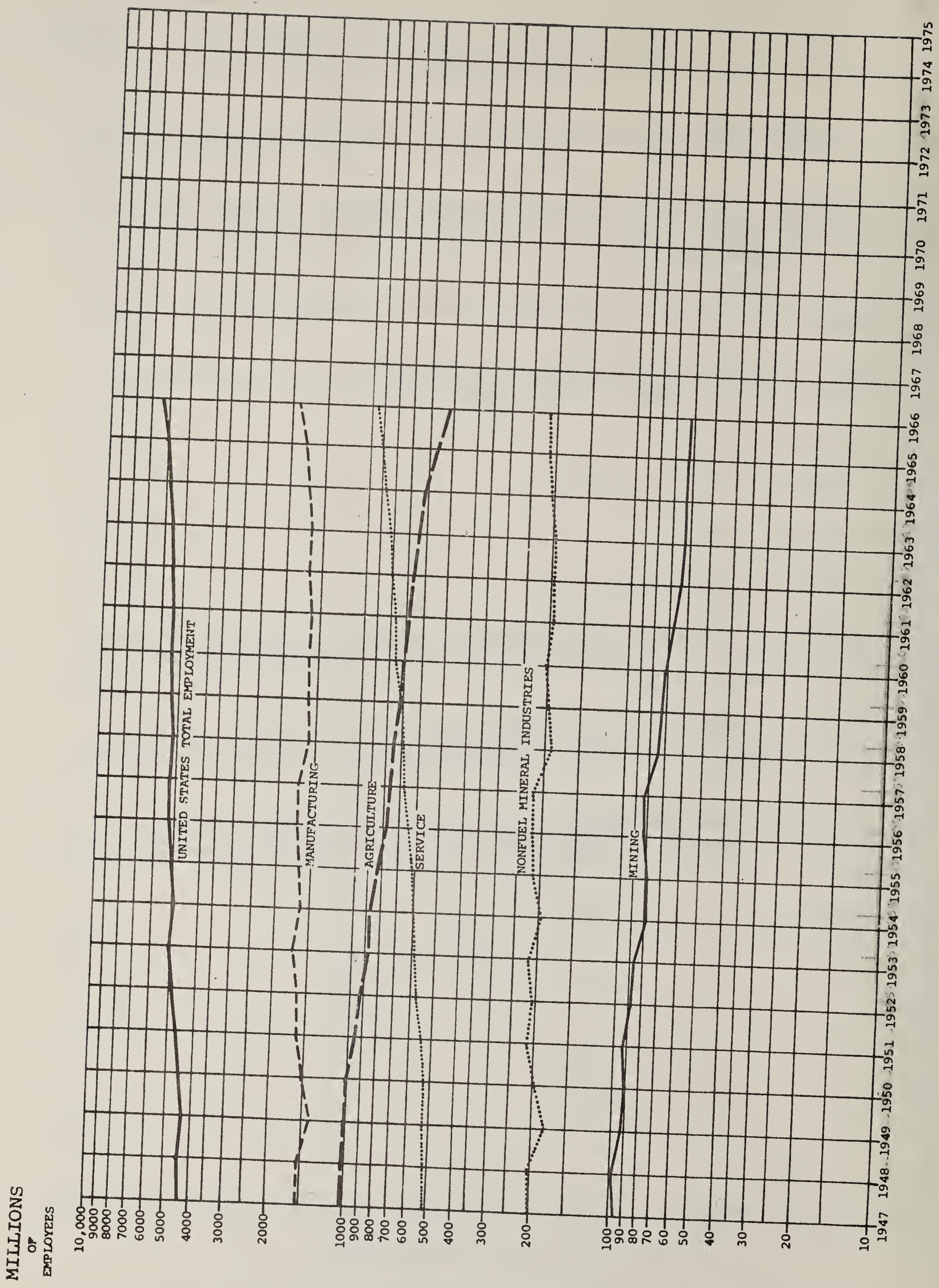


Fig. 21 - Employment in the United States by major economic activity.

CHAPTER 11

NONFUEL MINERALS IN THE ECONOMY

What is the role of the nonfuel mineral industries in the economies of the United States and each of the 11 Western States? Has it changed since 1860 or 1947?

A. MINERALS AND THE NATIONAL ECONOMY

1. Minerals and Employment

In 1860, approximately 170,000 persons were gainfully employed in mining in the United States. This represented about 1.6 percent of a total national employment of more than 10.5 million. At the same time nearly 60 percent of the nation's gainfully employed were found in agriculture and another 18 percent were occupied in construction, manufacturing, and "hand trades."[14]

By 1910, the number employed in mining exceeded a million and by 1920 mining jobs accounted directly for almost three percent of the nation's employment. Thereafter, however, as the adoption of scientific management and the growth of strong industrial unions led to greater labor productivity in heavy industrial activities, mining employment declined in both absolute and relative terms. By 1947, mining employment had dropped to only 943,000, about 1.6 percent of the nation's total civilian employment.[15] Since then, employment in the industry has declined rather steadily as labor productivity has grown. By the end of 1968, average employment in all United States mining had fallen to 625,000.[16]

The total employment in domestic mining at the end of World War II amounted to only 2.2 percent of the near by 44 million people employed in the whole economy. In the years to follow, a downward trend characterized mining employment. Primarily as a result of technological change, absolute magnitudes were declining along with relative ones. By 1968, employment in mining had declined to 625,000 – less than one percent of the nearly 76 million employed in the United States.

In the nonfuel mineral industries as a whole, however, the number employed was greater in the late 1960's than it had been in the late 1940's. The absolute number in all nonfuel mineral activities vacillated about the two million mark, while the percentage of total employment represented declined gradually from 4.6 to 3.4 percent. Here also a rather stable level of employment became quantitatively less significant as the total economy expanded. The nonfuel mineral industries includes metal mining, mining and quarrying of nonmetallic minerals other than fuels, stone, clay and glass products manufacture, and primary metal industries.

Agricultural employment has also declined in relative importance, from 24 percent of total employment to little more than eight percent since 1947. Though the actual number employed in manufacturing has increased from around 15 to more than 20 million, the relative number of workers employed in this sector has also declined from 35 to 30 percent of the nation's total employment. In contrast, the growth of the service industries is reflected in the employment figures. The increase from slightly more than five million to slightly less than 10 million since World War II represents a relative increase from nearly 12 percent of the total in 1947 to almost 15 percent in 1968.

Wage and salary disbursements in the nation's mining industries in 1947 amounted to almost three billion dollars, and then increased by nearly 55 percent by 1966 to over $4.5 billion. Since the total of wage and salary disbursements in the economy as a whole increased more than 200 percent in the same period, however (from $121 billion to $391 billion), the relative share of wages and salaries going to the mining industry fell. Mining

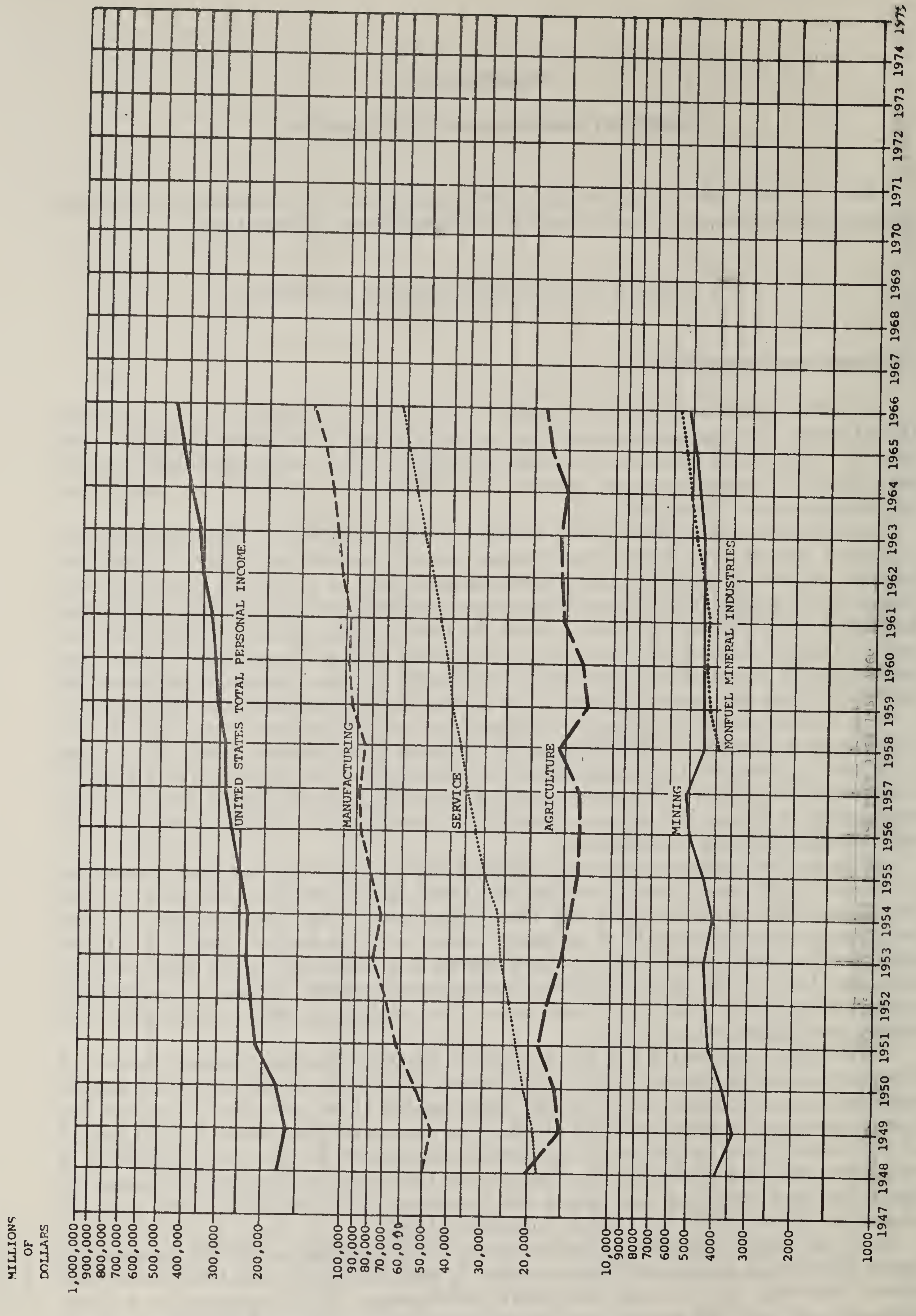


Fig. 22 - Civilian personal income received for participation in current production in the United States.

received 2.4 percent of the nation's total wages and salaries in the years immediately after World War II but only about half that percentage in the late 1960's. The share accruing to agriculture and manufacturing likewise declined, while those employed in both private services and government enjoyed relatively larger portions of the country's total wages and salaries.[17]

2. Minerals and Personal Income

In the years since 1947, total civilian income received for participation in current production in the United States has been about six trillion dollars. This includes wage and salary disbursements, other labor income, and proprietors income. Of this total, just over 1.5 percent has been contributed directly by the mining industry. In relative terms then, the share of income derived directly from mining activity assumes a rather inconsequential standing among other major personal income-generating sectors of the economy. Two other points must be kept in mind, however, when assessing the 20 year impact of approximately $90 billion in mining income on the nation's economy. The first is that in absolute terms this income is very large, and as such it is also of vital importance to the geographically concentrated mining communities. The second is that significant multiplier effects work on this income. When mining income is spent, additional income is generated for other supporting sectors of the economy. Furthermore, those products of mining activity serve as vital inputs for numerous other income generating activities.

Mining income has gradually but consistently increased in the United States. In a dynamic economy, however, absolute increases in one sector may not be sufficient to maintain a position relative to other more rapidly developing sectors. Such proves to be the case both in all mining and in the nonfuel mineral industries. While total personal income was rising by more than 160 percent (from a level of about $174 billion in 1948 to a level of $458 billion in 1966), mining income rose by only 30 percent (from just under $4 billion to just over $5 billion). Mining's share of total income received for participation in current production has thus consistently declined. It represented about 2.3 percent of the national total in 1947 but no more than 1.0 percent of the total by 1968. On the other hand, the relative position of agriculture underwent a slight climb from 11 percent of the total at the end of World War II to 14 percent over two decades. Manufacturing, however, also rose, but by a greater amount.

3. Critical Items

The greatest contribution of the mineral industries to the national economy lies, of course, not in their direct employment nor provision of personal income, but in the mineral products themselves that are provided and in turn form the bases of myriad other economic activities. In fact, the ready availability of mineral commodities is a virtual necessity for the economic health of any nation. Whether or not that availability must come from internally developed resources depends on the size of the nation involved. For example, Switzerland and Denmark have developed fairly prosperous economies without any minerals industries to speak of. As far as individual states are concerned, Delaware and Rhode Island have also developed pretty properous economies without any minerals industries to speak of. So it can be done, but these are all small areas. A larger country or state almost has to have a diversified economy. It must have an economy that is not dependent upon other economies and upon actions in those other economies. It must have its own sources of raw materials if it is going to be independent, if it is going to be prosperous, if it is going to govern its own future. Small countries or small states may have other features which allow them to be prosperous, but they are not necessarily going to be as independent as they would be with an internal source of industrial raw materials.

It can be asked if history doesn't show that the raw materials producing countries are not usually the less developed countries of the world Such a question can be answered in the affirmative if nations such as Canada, Australia, Russia, and the United States are excluded. It is true that mineral industries are highly developed in many lesser developed areas of the world. This is so primarily because, throughout the course of history, the mineral industry has typically been the first step away from subsistence agriculture in the economic development process. It is difficult to think of a single country that has gone beyond an agricultural economy where this has not been the case. For the most part in economic development, the process extractive industries (not including agriculture) have been the first step beyond agriculture in developing an industrialized society. Throughout the world today, there are various areas in various stages of economic development. Some of these are just beginning, and that is where attention is focussed as far as the mineral industry is concerned, except of course for the United States, Russia, Canada, Australia, and some others. It is true that economic wealth flows to those countries exercising technological superiority and superior labor productivity. One of the first steps toward increasing labor productivity is the development of a mineral industry using capital equipment and providing raw materials for manufacturing that are not found in agricultural economies.

It is frequently mentioned by those who would insist that a healthy minerals industry is not vital to a healthy economy that there are examples of vigorous economies in "non-mining" countries such as Japan, Britain, and to a lesser extent most of the nations of Western Europe. These are perfect examples of what has just been said. In Britain, tin mining at Cornwall was one of the oldest mining industries of which we have knowledge, and it was one of the earliest industries in Great Britain. The Industrial Revolution, which is generally said to have taken place largely in Great Britain, occurred there not only because of the inventiveness of the people, but because they had coal and iron. They had power and they had industrial raw materials. Even though Great Britain may not be one of the world's leading mineral producers now, it is still an important producer of coal and iron, and this has been a base for industrial wealth. Japan has coal, and coal has also formed the basis for American industrial development. Even earlier, Japan had sources of other metals in continental Asia that were, in effect, under the control of Japan even if they were not part of the Japanese archipelago. As far as Western Europe is concerned, Germany, France, Belgium, and Sweden (all of the highly developed economies) have strong mineral resources. The heart of industrial Europe is the coal and iron region in Germany and France. That is where European industry started and where it has kept going with resources from other parts of the world. Industrial Europe started its industrial development with a highly successful mineral industry.

The same can be applied, of course, to the United States. The industrial development that took place along the East Coast and then moved out into the Great Lakes region was a result of the availability of mineral resources there. Iron, coal, and limestone were available on the East Coast, and in the Midwest iron, coal, and limestone were available too.

There are, of course, a number of small advanced nations with non-existent or relatively minor mineral industries. These would include Switzerland, the Netherlands, and Israel. It should be pointed out, however, that these countries have had, and still have, ready access to the minerals of other nations. And they are all small.

B. MINERALS AND THE WESTERN STATES

1. The Western States and the National Economy

From the end of World War II to 1968, civilian income received by persons for participation in current production in the United States increased from less than $175 billion to nearly $500 billion. This represents an increase of almost 200 percent for the period. As shown in Figure 23, the expanding incomes generated in the United States were accompanied by similar growth in the Western States. The income generated by all economic activity in both the Mountain and Pacific Coast States combined climbed from the 1948 level of nearly $25 billion to slightly in excess of $79 billion in 1966, an increase of almost 216 percent. Thus, income growth in the Western States has exceeded that of the nation as a whole.

Of the total income generated in the national economy between 1947 and 1966 (substantially in excess of $53 trillion), more than 16 percent (nearly $9 trillion) represented economic activity in the Mountain and Pacific Coast States. The West's share has also grown from about 14 percent in 1947 to more than 17 percent at the end of two decades.

As shown in Figure 24, the last 20 years have seen a more rapid increase in the employed labor force of the 11 Western States than in the total employment in the United States as a whole. At the end of World War II, more than 5.3 million workers were employed in the West, representing nearly nine percent of the more than 60 million workers in the entire economy. By the end of 1966, slightly more than 10 million were employed in the Pacific and Mountain States, representing more than 13 percent of the nearly 76 million workers in the country's employed labor force.

2. Mineral Industry Employment in the West

Not surprisingly, the employment trend in Western States mining has not been dissimilar to trends in the national mining industry. As can be seen from Figures 25 and 26, the 1947 output of western mines required a total of roughly 115,000 workers, about two percent of the region's total employment. By 1966 the number of miners had made a slight absolute increase, but those then employed in the mines represented only about one percent of a much more rapidly growing total regional employment. In the nonfuel mineral industries as a whole, the absolute expansion was more marked and the relative decline more gradual than in the mining industry alone.

In spite of the fact that the numbers employed in mining represented a declining proportion of total employment in the West, every western state except Washington seemed to hold its own with reference to the absolute numbers employed in mining since 1947. In Arizona and New Mexico, there were steadily increasing numbers of workers drawn into mining. In most of the states no clear trend can be perceived, as most seem to have fluctuated around a mean level of employment somewhere between the values prevailing at the beginning and end of the period. A slump in western mining employment coincided rather closely with the recession of 1958, in the aftermath of which the process of recovery was slow and for the most part rather difficult for the western mining industry.

In employment terms, the mining industry of the Pacific Coast States is only about half as large as that of the Mountain States. Moreover, total employment has declined both relatively *and* absolutely in California, Washington, and Oregon in the course of the two decades since World War II. Pacific States mining employment was 39,000 in 1947, representing less than one percent of total regional employment. The number of workers employed in the mining industry of the three Pacific States reached a peak of about 41,000 in 1953. Since this growth was slower than the growth of total regional employment, however, this number of workers represented a smaller percent of all Pacific Coast workers.

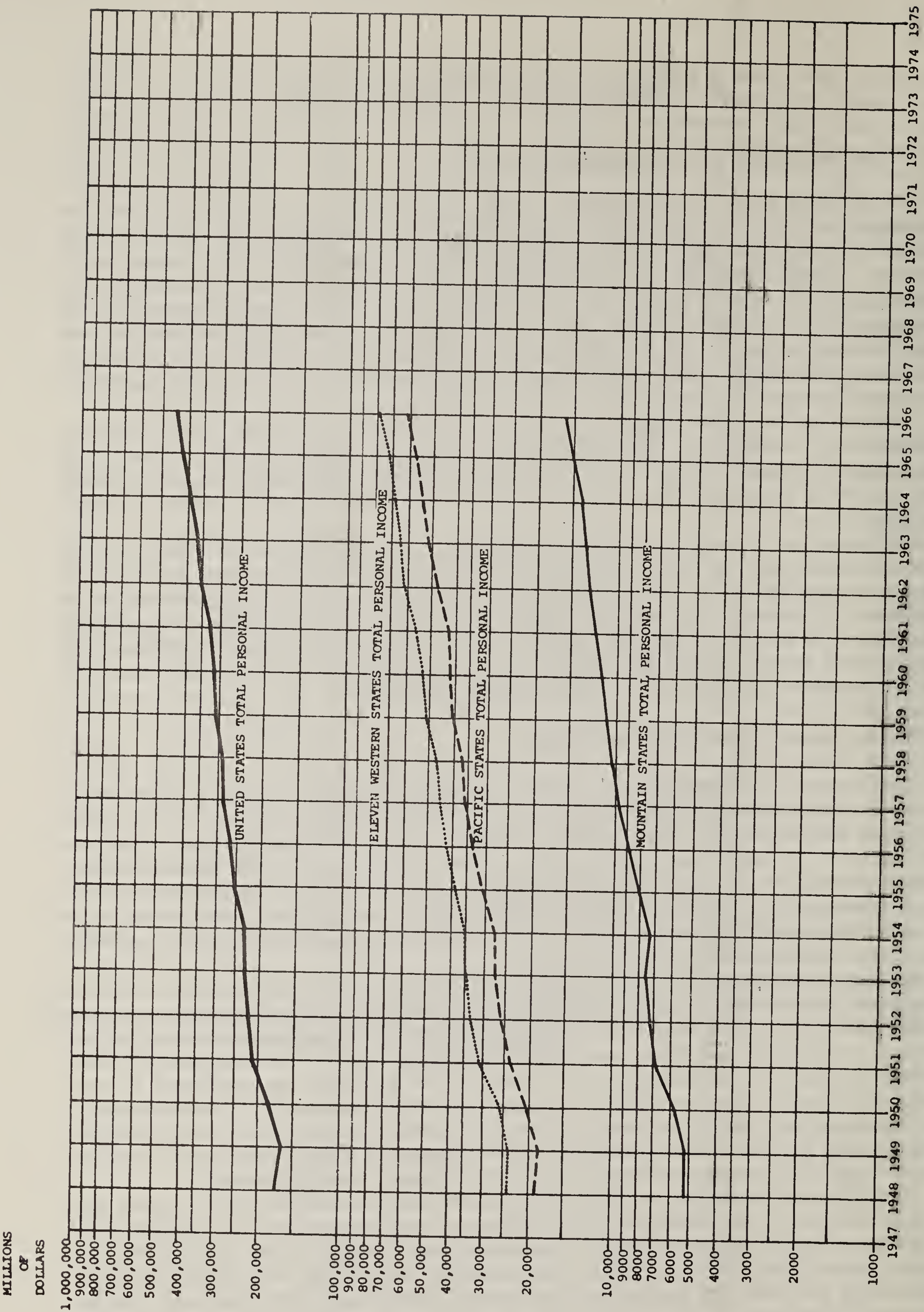


Fig. 23 - Civilian personal income received for participation in current production in the Pacific, Mountain, 11 Western States, and United States.

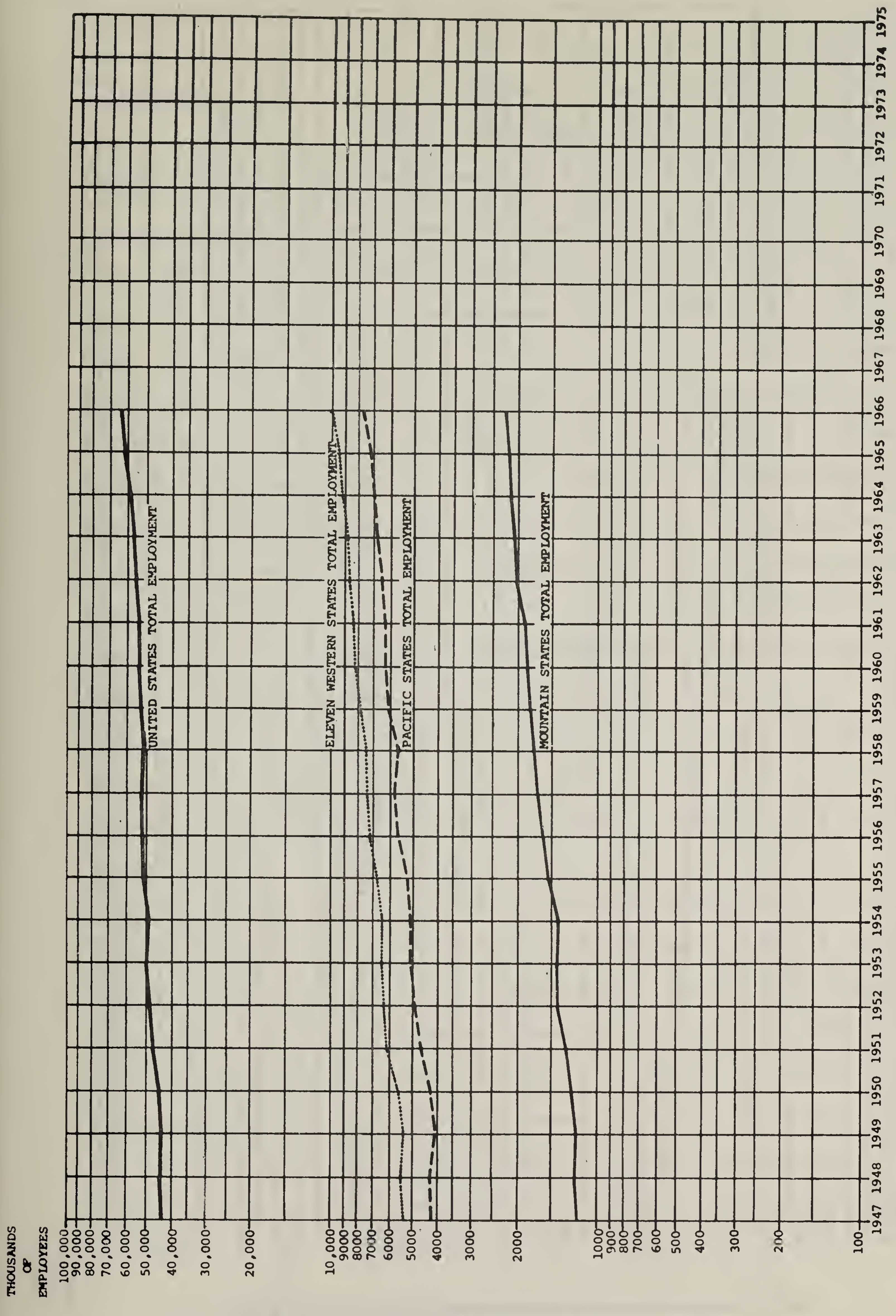


Fig. 24 - Employment in the Pacific, Mountain, 11 Western States, and United States.

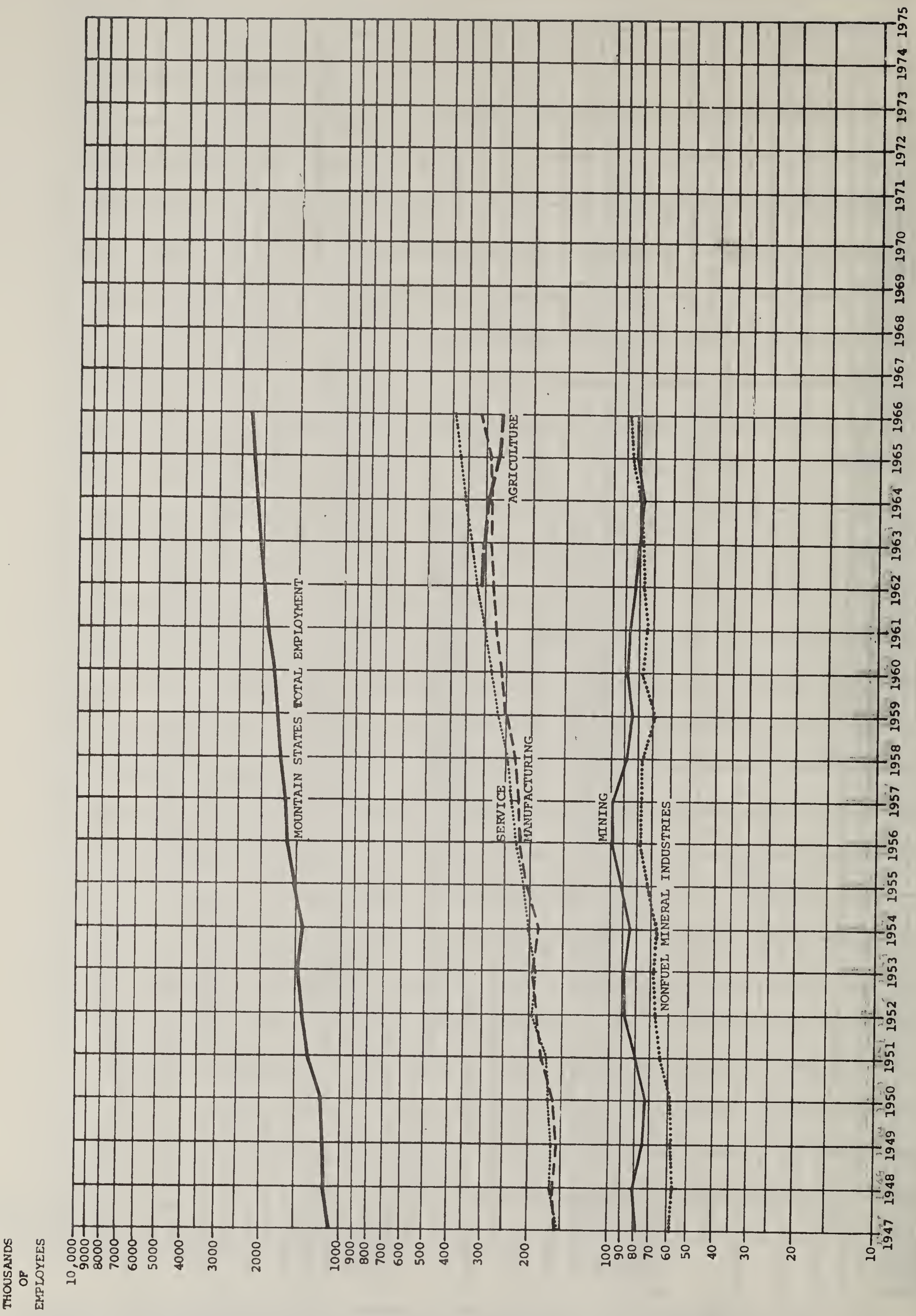


Fig. 25 - Employment in the Mountain States by major economic activity.

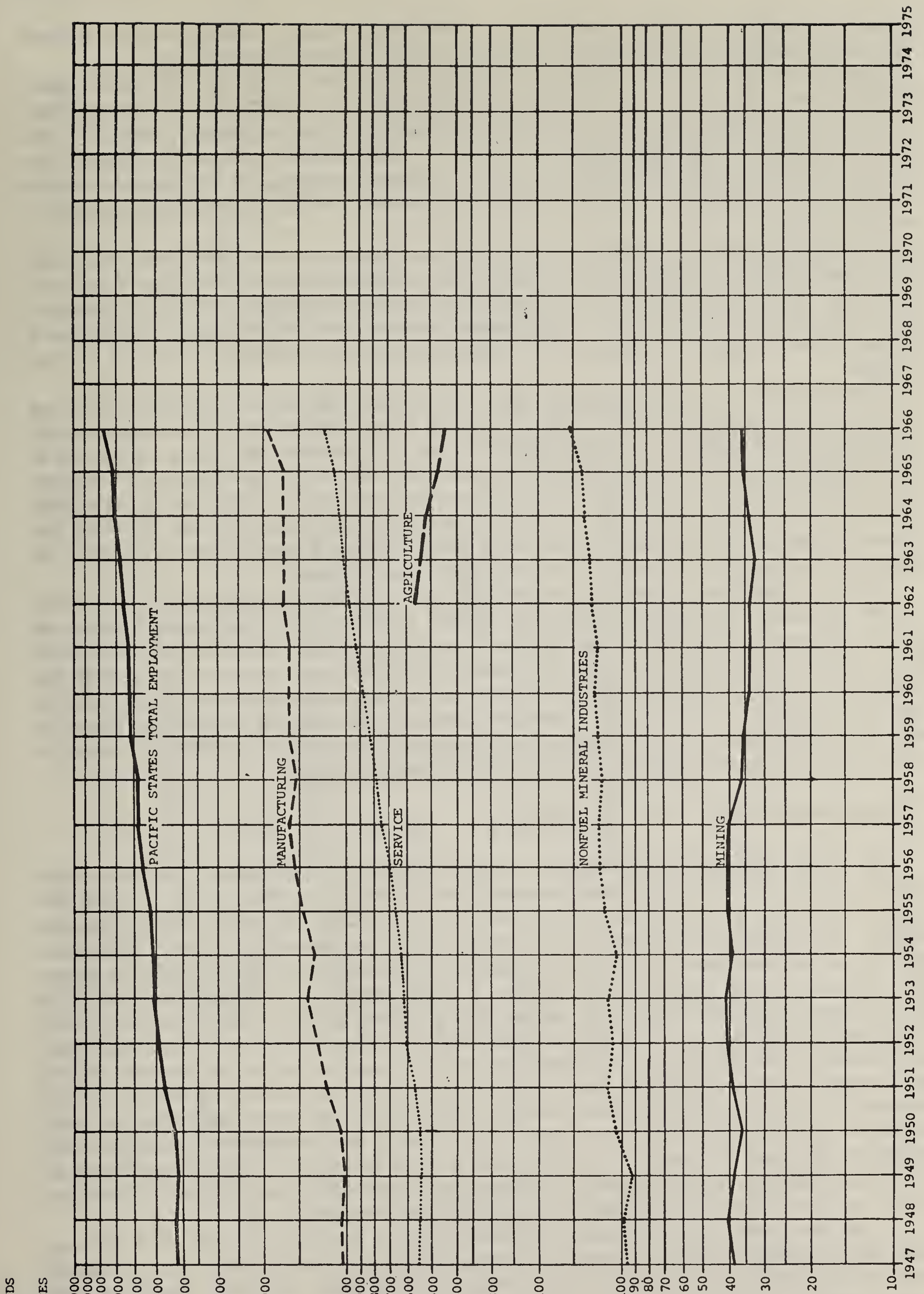


Fig. 26 - Employment in the Pacific Coast States by major economic activity.

In spite of a slight recovery after 1963, by 1966 Pacific regional mining output required only about 36,000 workers or only 0.5 percent of the total number employed.

Employment in all nonfuel mineral industries on the West Coast in 1947 was roughly 95,000, about two percent of the region's employment. Once the relative standing of the mining industry reached the 1951 peak of 2.5 percent of total employment with 116,000 employed, the industry experienced a rate of employment growth slower than that of the entire three-state-region. In 1960 the 152,000, persons employed in the nonfuel mineral industries on the Pacific Coast were only two percent of the Pacific States aggregate employment.

Mining employment for the Western region as a whole, i.e., both Pacific and Mountain States, amounted to more than 12 percent of all employed labor in the nation's mines in 1947. By 1966, almost 20 percent of United States mining employment was in the Western States. As for the West's share of total employment in the nonfuel mineral industries, it increased from nearly nine percent of the United States total in 1947 to almost 11 percent in 1966.

Employment in manufacturing and service industries in the Western States has grown as rapidly as or even more rapidly than total Western States employment. Thus, employment in Western service industries has increased from about 13 percent to roughly 16 percent of total employment since 1947. Manufacturing employment has fluctuated around 25 percent of total employment in the Pacific Coast States and around 13 percent in the Mountain States. Large absolute gains in numbers employed have been enjoyed by both the manufacturing and service sectors in all the 11 Western States. For the region as a whole, the labor force employed in non-basic sectors has more than doubled.

Mining employment actually has increased only in the Mountain States. In the nonfuel mineral industries, significant employment growth has also been experienced. The rate of growth of these industries has been markedly greater for the Pacific and Mountain States than for the United States economy as a whole. In several cases, employment in both the mining and nonfuel mineral industries in the Pacific Coast and Mountain States actually increased between 1947 and 1968. Generally, however, the absolute numbers employed in these activities declined along with the relative share of total employment represented by the number of workers actually on the payrolls of these industries.

3. Minerals and Personal Income in the West

The trend most strikingly observable in United States mining has been that the civilian income derived therefrom has been increasing since 1947 in absolute terms but that the share of total income represented by earnings from mining has been growing steadily smaller. An investigation of data for the Pacific Coast and Mountain States demonstrates that the trends mentioned above also characterize these individual public land area states. For the period from 1948 to 1966, civilian incomes accruing to persons participating in minerals production amounted to an excess of four billion dollars in California, two billion dollars in New Mexico, and one billion dollars each in Arizona, Colorado, Montana, Utah, and Wyoming. California's mining income, by far the largest in the entire Western region, represented a rather negligible share, however, of the total income generated by all economic activity within that state. Mining contributes a relatively small share to total civilian income in the other two coastal states, Oregon and Washington. Mining income represents less than one percent of total state income for all the Pacific Coast States. In 1966, the combined mining income for Oregon and Washington was only $33 million, less than a quarter of the income generated by mining in Arizona alone.

In the Mountain States (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming), civilian income received for participation in the production of mineral commodities totalled almost $10 billion from 1948 to 1966. In 1948, when the total income generated by Mountain States mines was over $300 million, that sume represented six percent of all income generated in the region. There was a total increase of mining

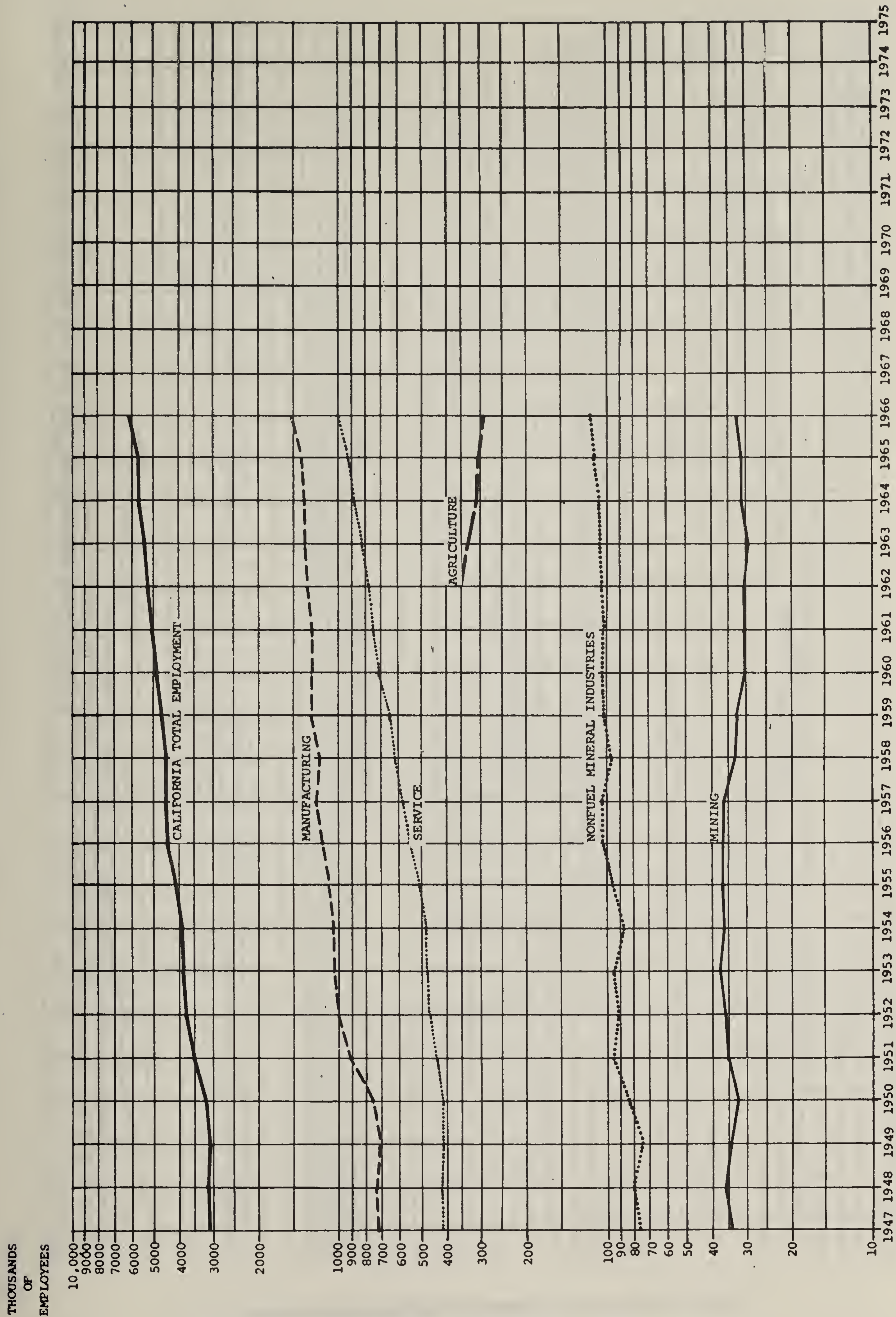


Fig. 27 - Employment in California by major economic activity.

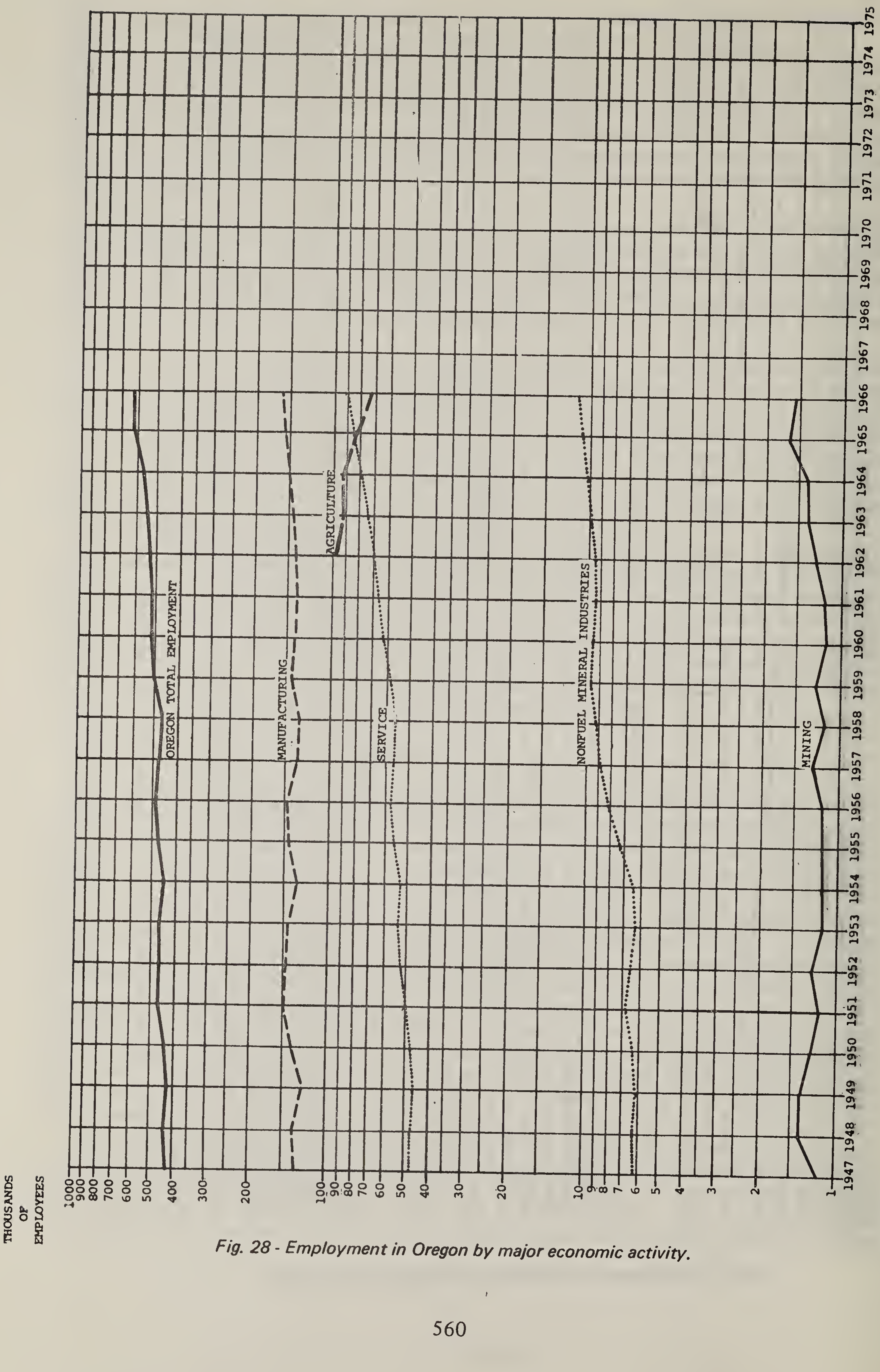


Fig. 28 - Employment in Oregon by major economic activity.

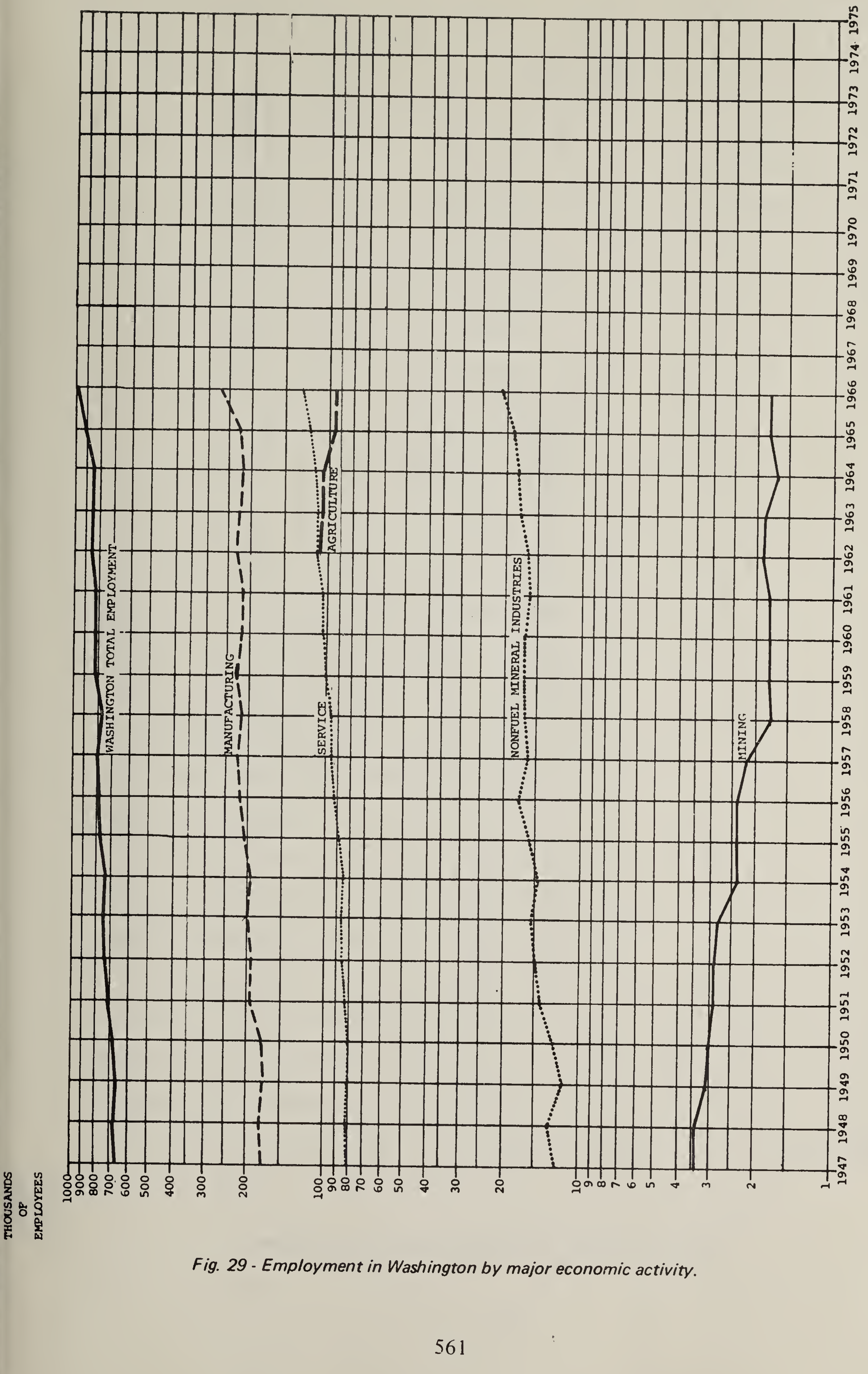


Fig. 29 - Employment in Washington by major economic activity.

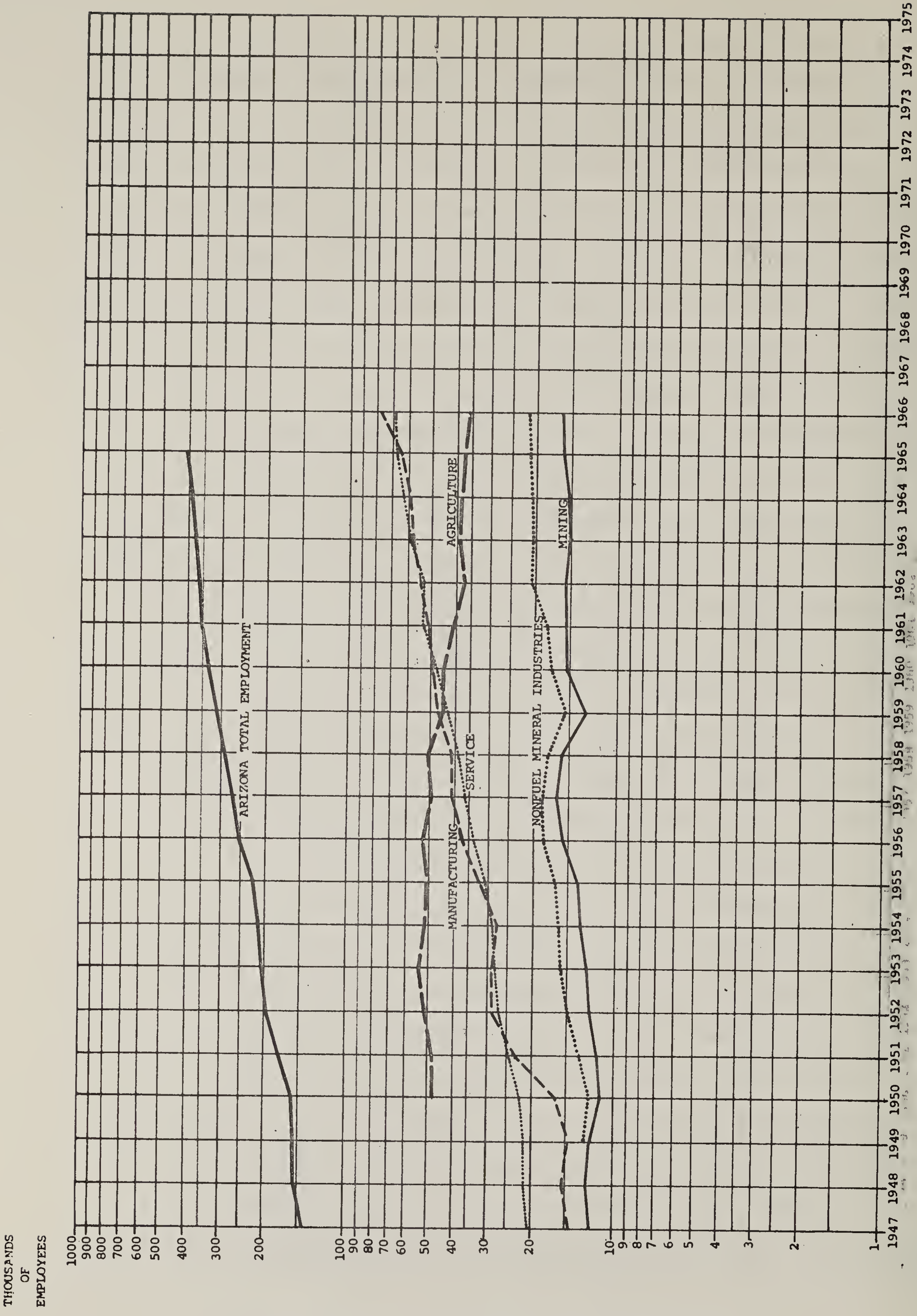


Fig. 30 - Employment in Arizona by major economic activity.

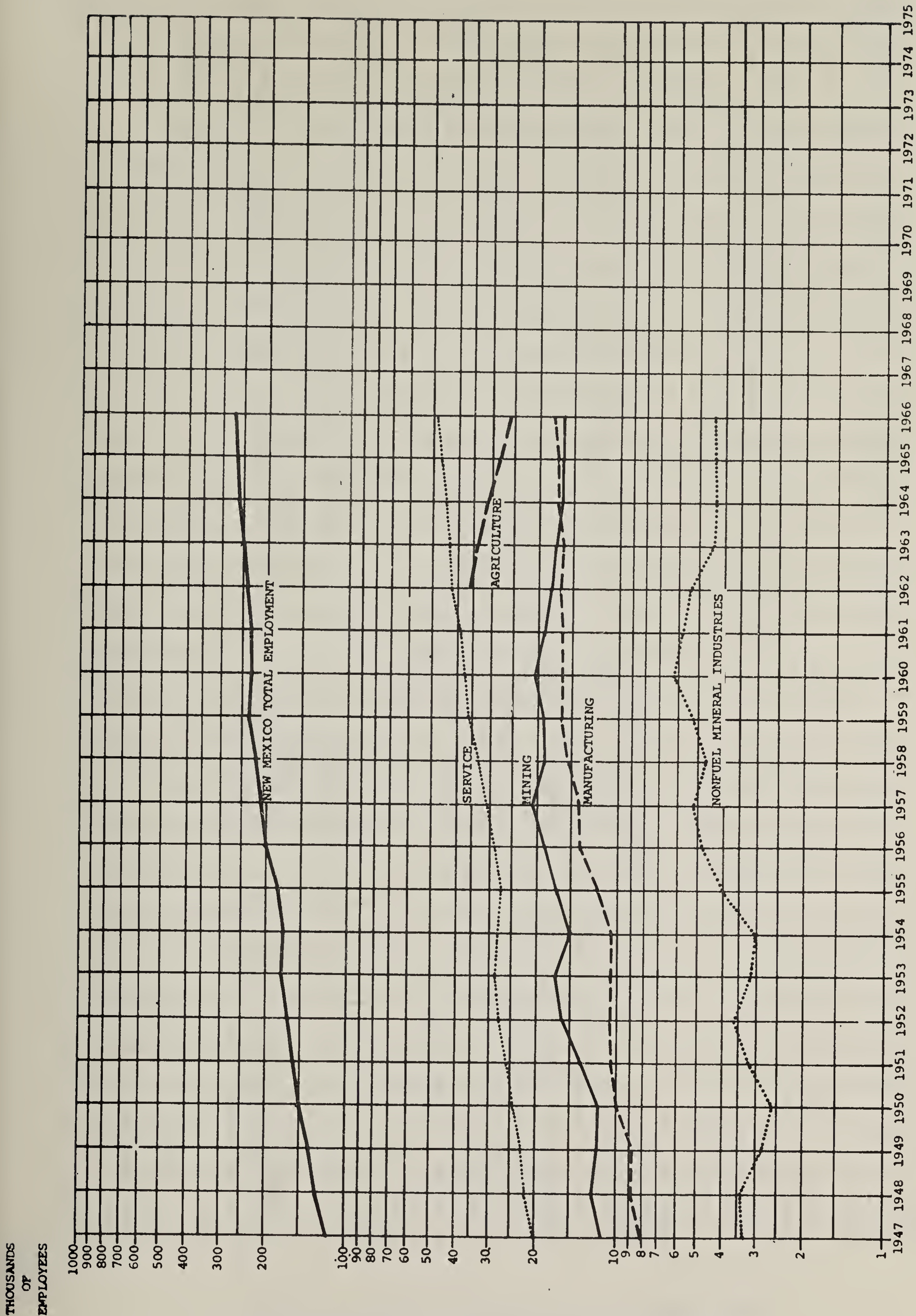


Fig. 31 - Employment in New Mexico by major economic activity.

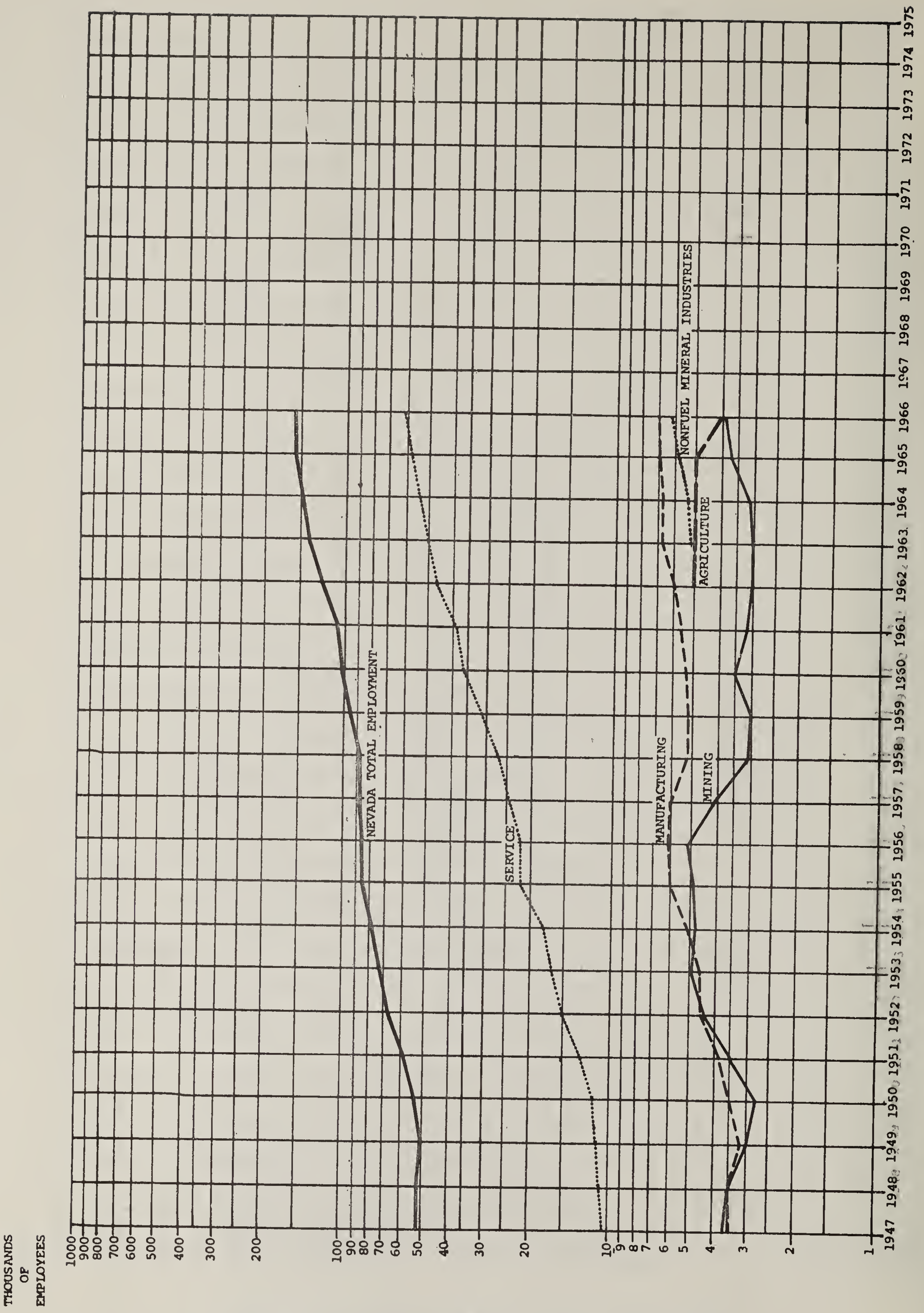


Fig. 32 - Employment in Nevada by major economic activity.

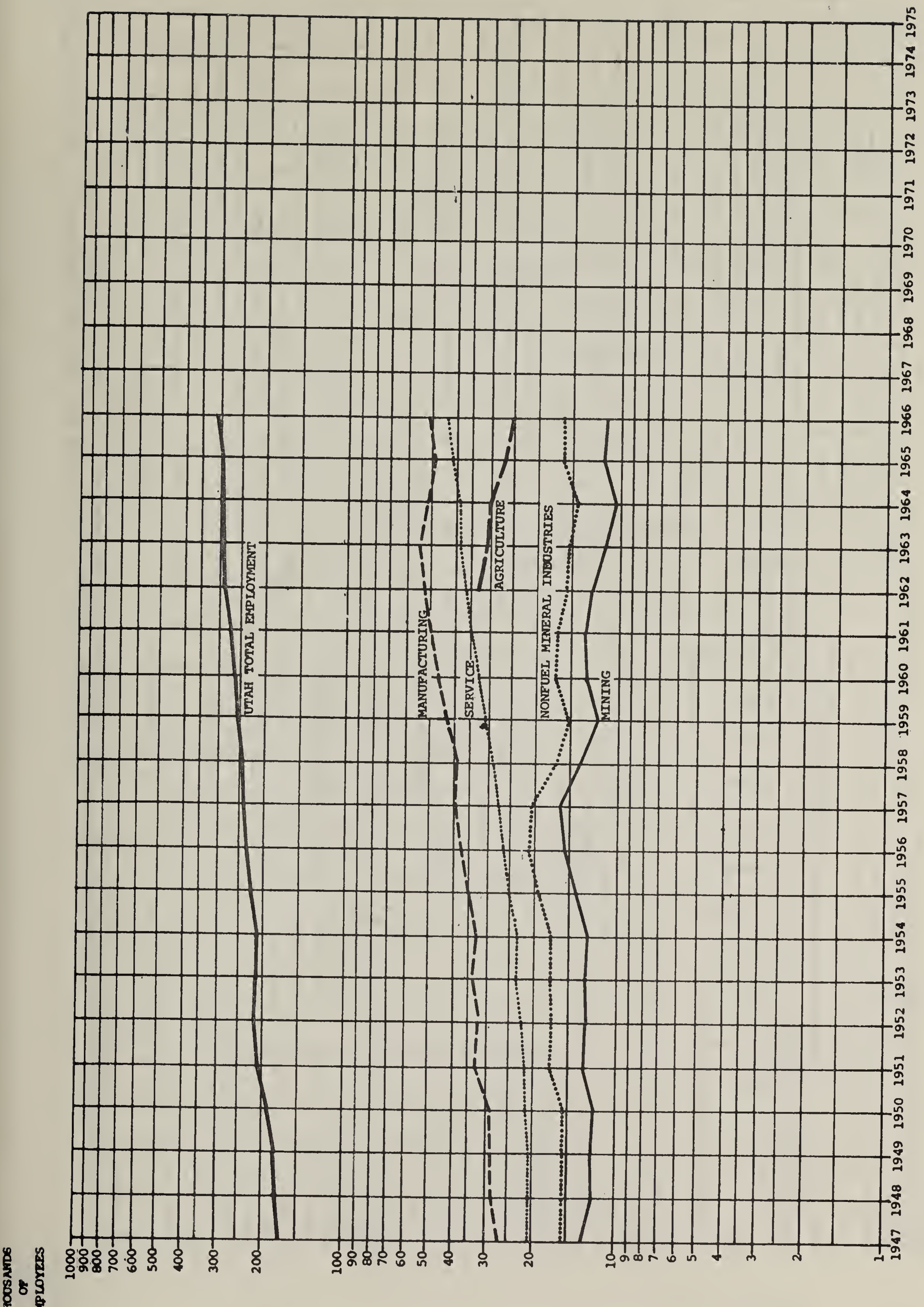


Fig. 33 - Employment in Utah by major economic activity.

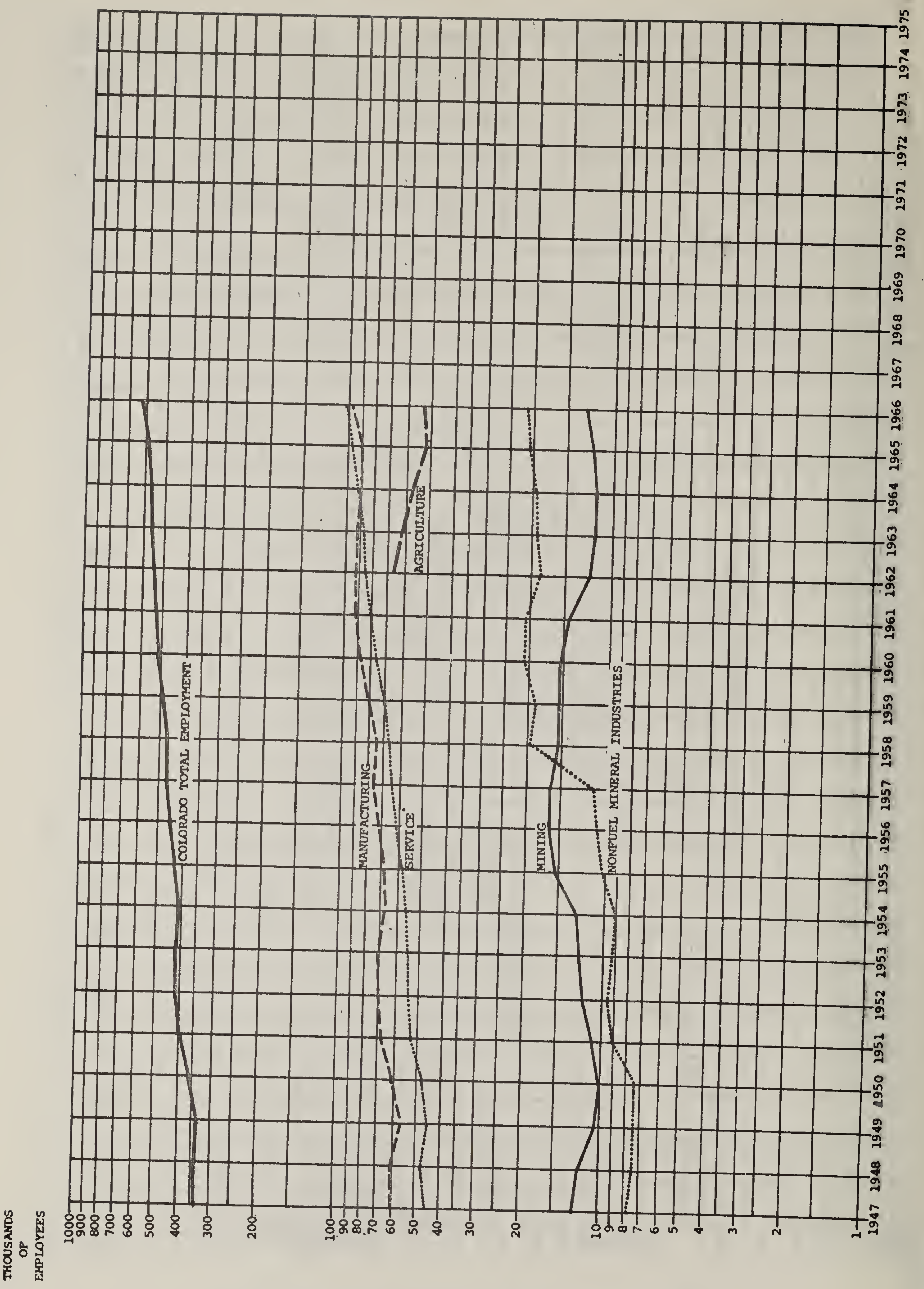


Fig. 34 - Employment in Colorado by major economic activity.

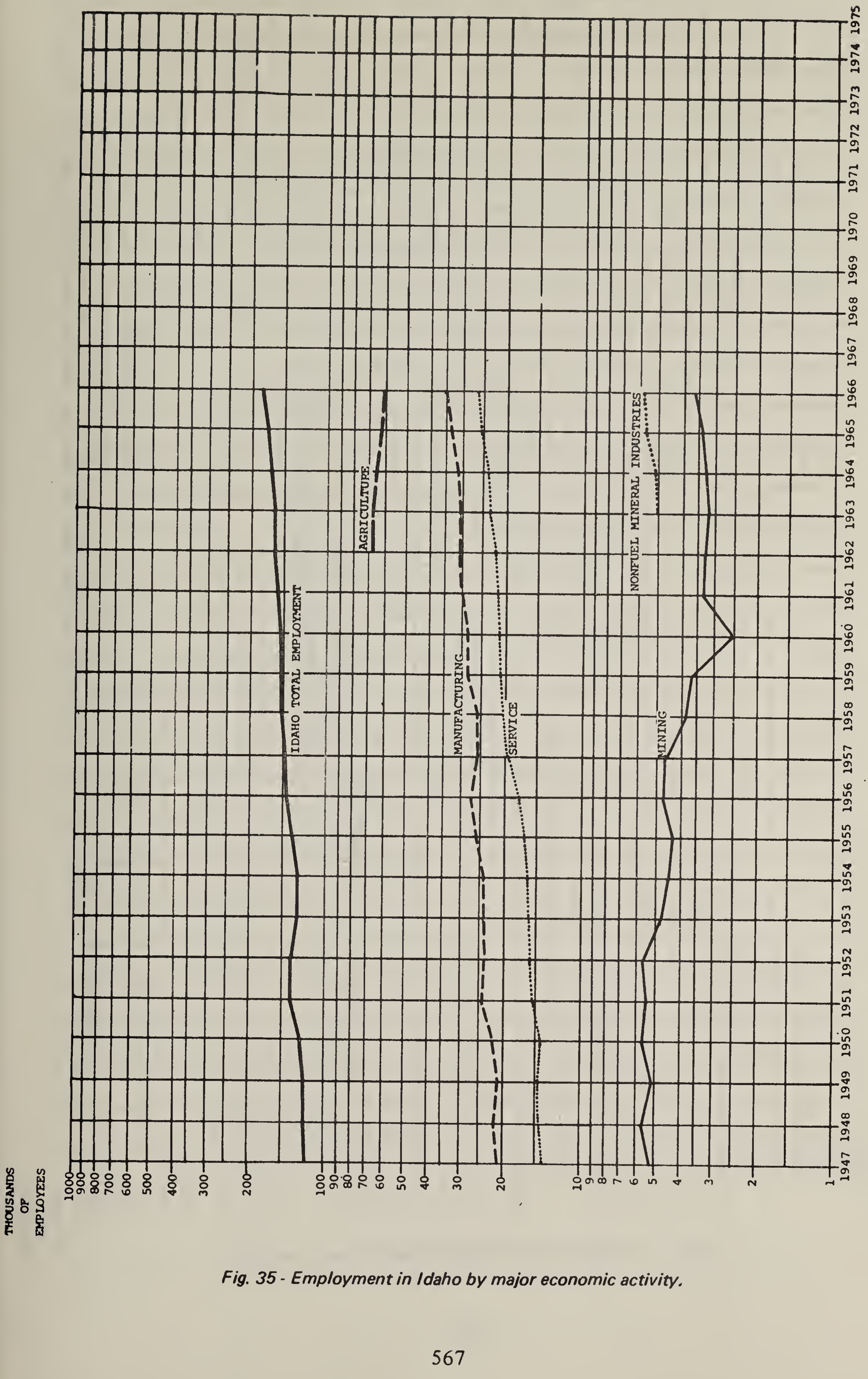


Fig. 35 - Employment in Idaho by major economic activity.

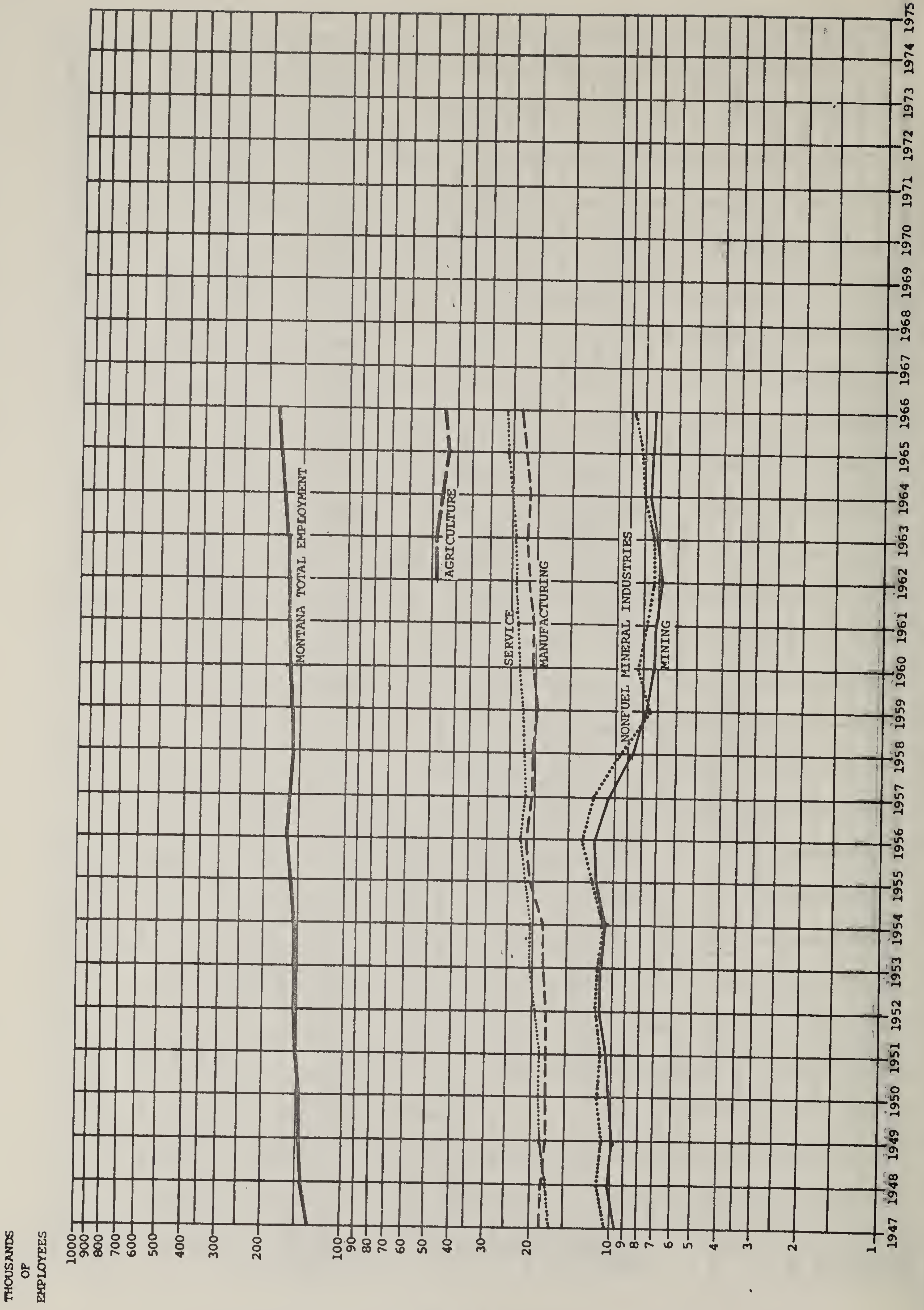


Fig. 36 - Employment in Montana by major economic activity.

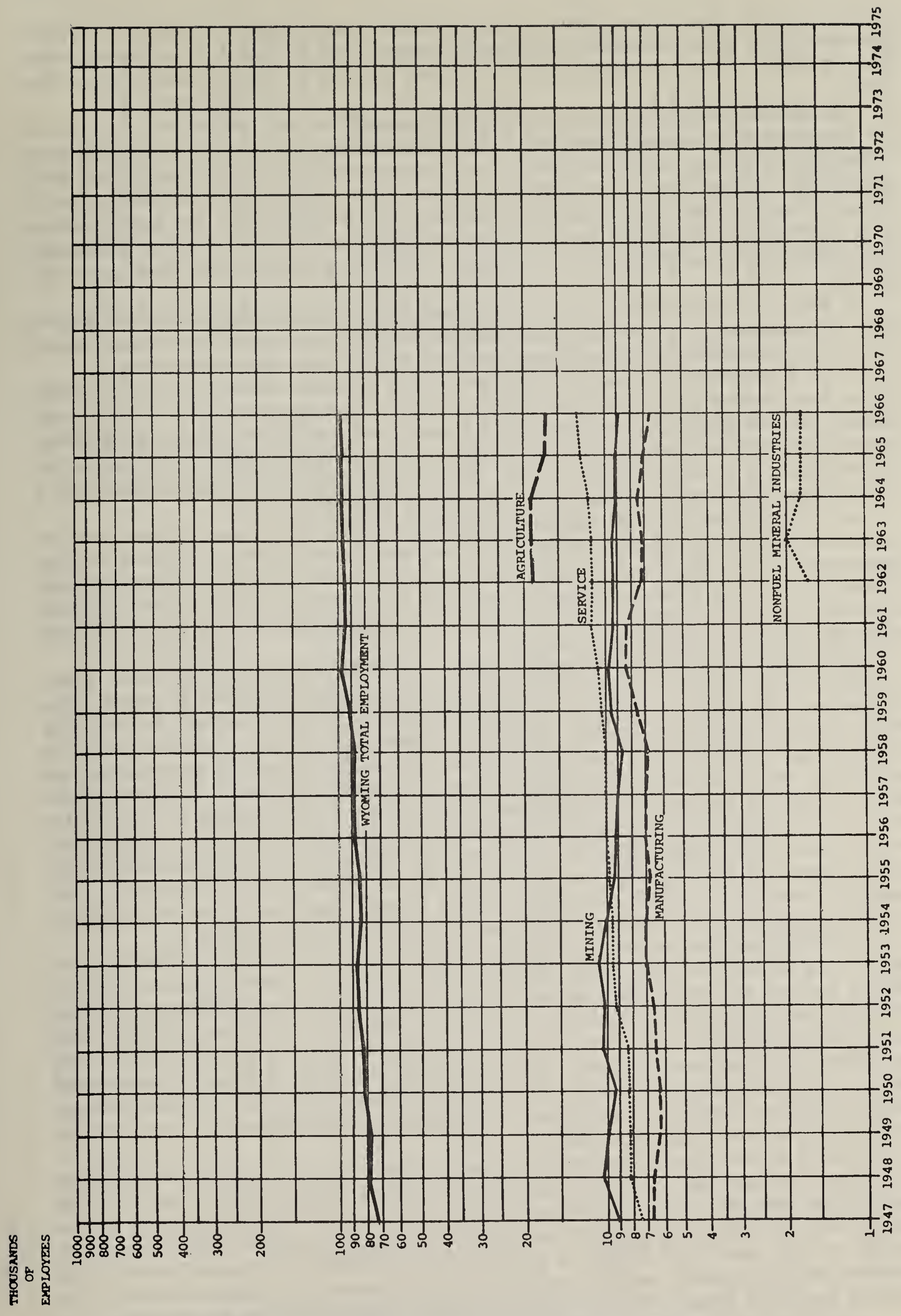


Fig. 37 - Employment in Wyoming by major economic activity.

income through 1966 of more than 120 percent. Since total income in the Mountain States increased after 1948 by almost 200 percent, however, the relative share of total income generated directly by the mining sector had declined by 1966 to less than five percent of the total.

Mining has actually represented a significant share of the total civilian income received for participation in current production in Arizona, New Mexico, Utah, and Wyoming since World War II. In Utah, mining has been a more important producer of personal income than agriculture. In New Mexico, by 1966, mining had taken a place of greater significance in terms of income generation than either manufacturing or agriculture. The same has been true of Wyoming. In Nevada, the relative contributions to personal income of agriculture and mining have reversed almost symmetrically, with mining becoming the more important industry.

In light of national trends, it is not surprising that the service and government sectors have both generated a greater level of civilian income and also experienced an improvement in relative standing among all the income generating sectors in the Mountain States.

In all of the Western States, the more spectacular sectoral increases in relative income shares have been in government and services, with the former advancing in an even more dramatic manner than the latter. The growth in government income has been predominantly at the state and local levels, a fact which holds for all of the Western States as well as for the United States as a whole. In most of the Western States, manufacturing has generated a rather stable share of total income at around 10 or 20 percent of the total.

As in the Mountain States region, the Pacific Coast States have been characterized by the increased relative standings of the service and government sectors in personal income generation. These sectors each claimed slightly in excess of 10 percent of total regional income in 1947. By 1966 the figure had climbed to 16 percent for each. Manufacturing increased from a 21 percent share of the total to more than 26 percent, while wholesale and retail trade declined from 23 to 18 percent.

Total mining income for the Western States, i.e., the Pacific Coast and Mountain States combined, amounted to nearly $15 billion for the entire 1948-1966 period. This represented almost 18 percent of all mining income for the United States as a whole during these nearly two decades. Moreover, the Western States share of total mining income in the United States is an expanding one. In 1948, the $512 million of civilian income generated directly by the mines of the 11 Western States represented only about 13 percent of the nation's total. By 1966 the amount had more than doubled, reaching nearly $1.1 billion for that year, representing a sigificantly expanded 20.8 percent of the nation's total civilian income received for participation in mining activity. The importance of the total amount of income generated by the mining industry is not to be reckoned merely by its size. The multiplier effects of a source of income are also of vital significance. Income multipliers have been calculated for each of the 11 Western States and are given in Table 1.

No attempt has been made to establish an income multiplier for the 11 Western States region as a whole, for these states do not really comprise a cohesive economic region. Massive leakages of spending from border states are characteristic. Eastern Montana, Eastern Colorado, and Eastern New Mexico, for example, are areas more geographically than economically associated with the Mountain and Pacific Coast States. Individual state multipliers were calculated, however, and will be discussed below. Because the leakages of income from the region in the border states are probably smaller than the interstate leakages within the region, it is quite probable that a regional income multiplier would be even larger than that of any of the individual states.

To illustrate the significance of the Western States' business and personal income multipliers, suppose that a rather small mining concern employing 50 men were to close down in the state of *Washington. In each two week period* for which this mine had no payroll, the 50 miners would (assuming they had received the average weekly earnings of miners in that state) lose directly a total of about $15,000 in personal income. The multiplier effects, however, would magnify this loss of income. Since these men (and their families) would no longer continue spending as they had done before the shutdown, the

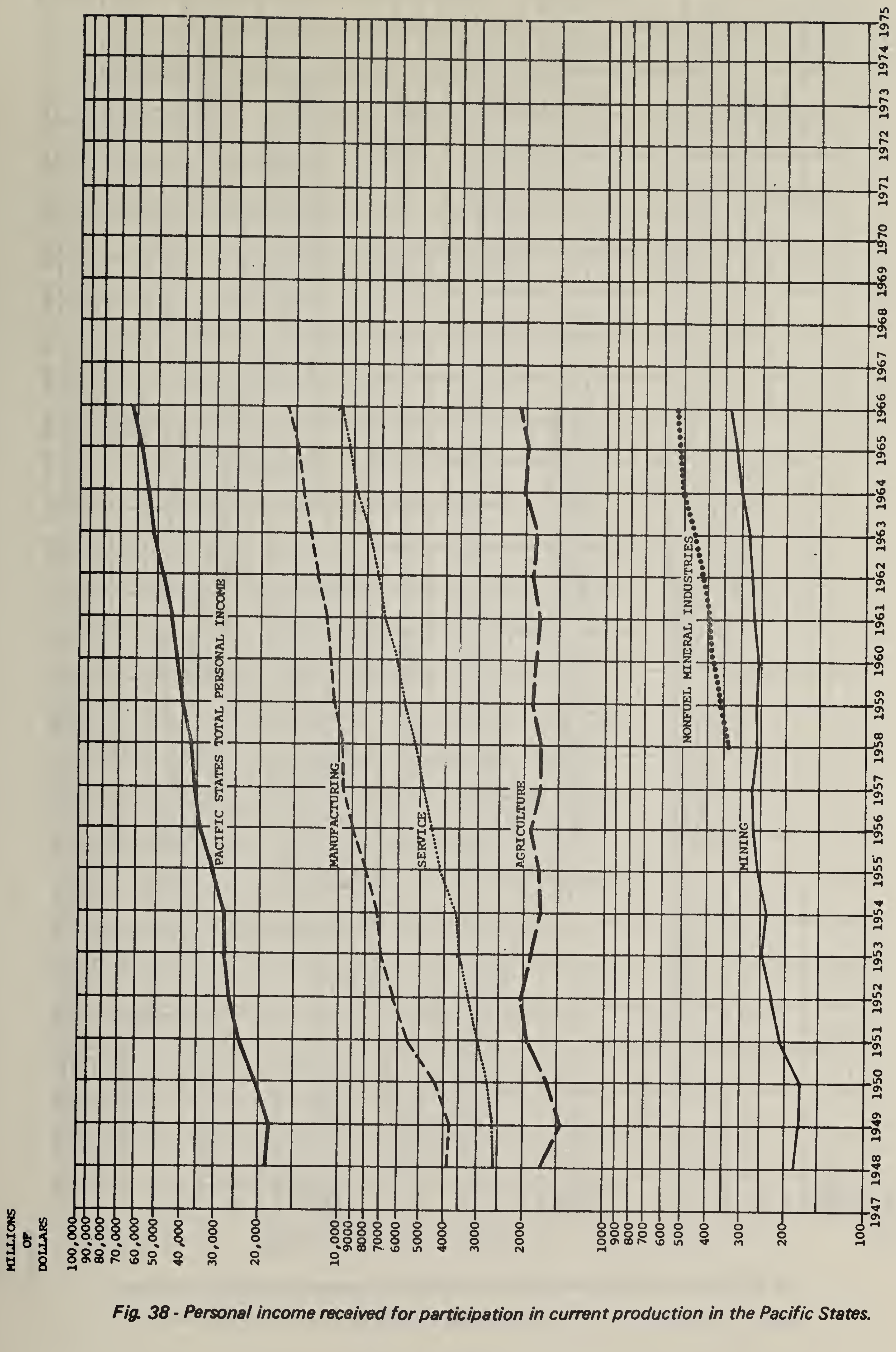


Fig. 38 - Personal income received for participation in current production in the Pacific States.

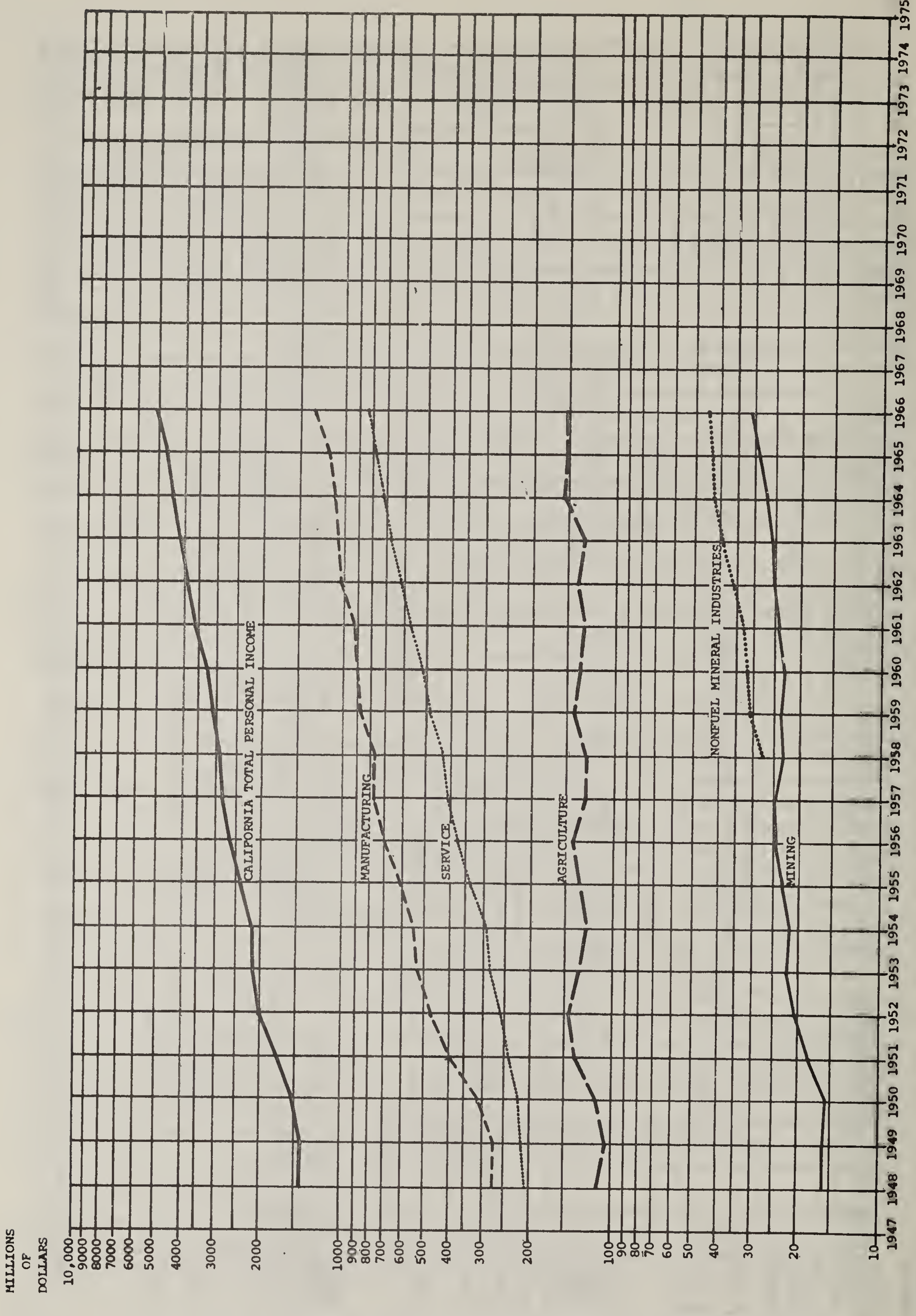


Fig. 39 - Personal income received for participation in current production in California.

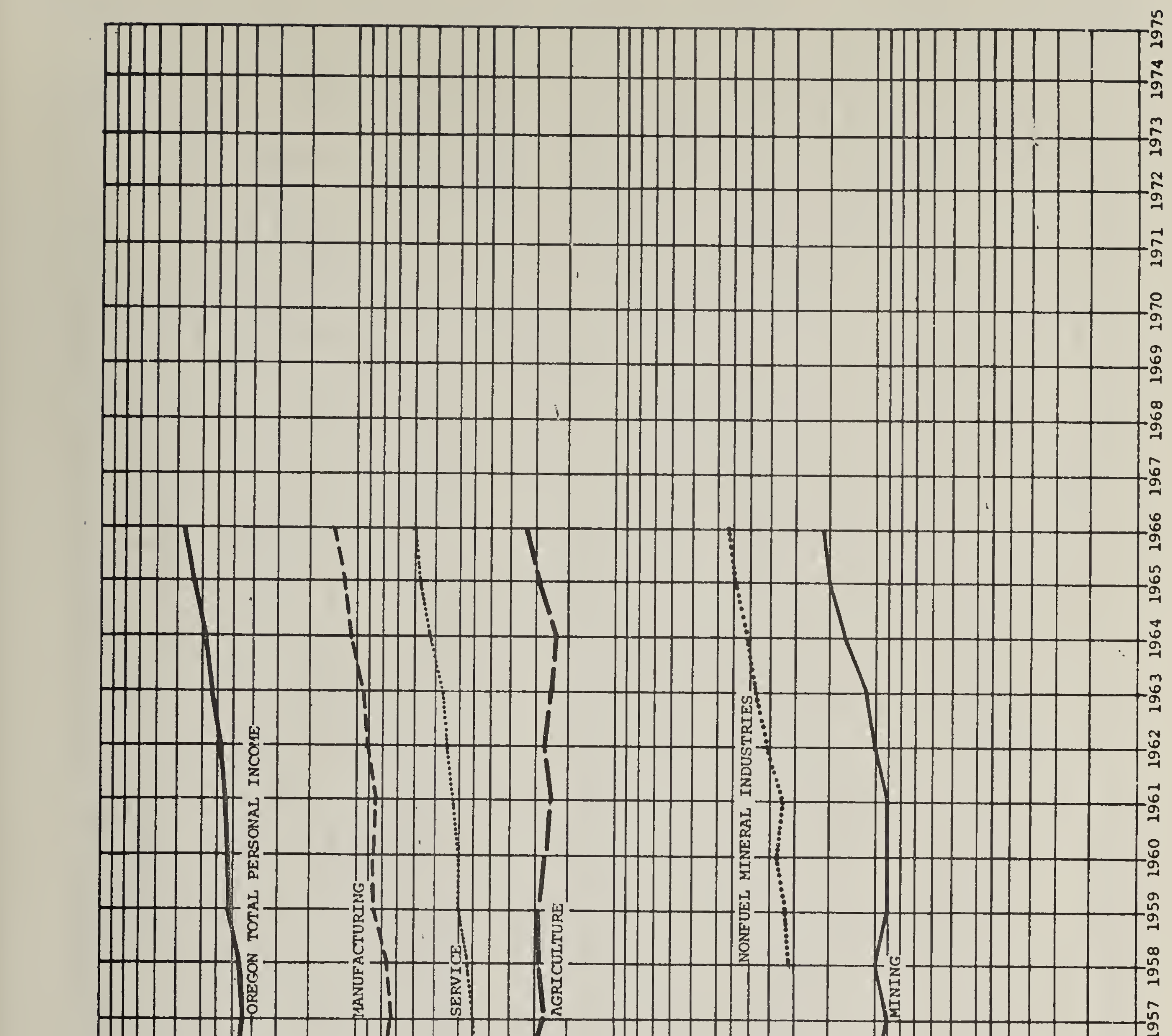


Fig. 40 - Personal income received for participation in current production in Oregon.

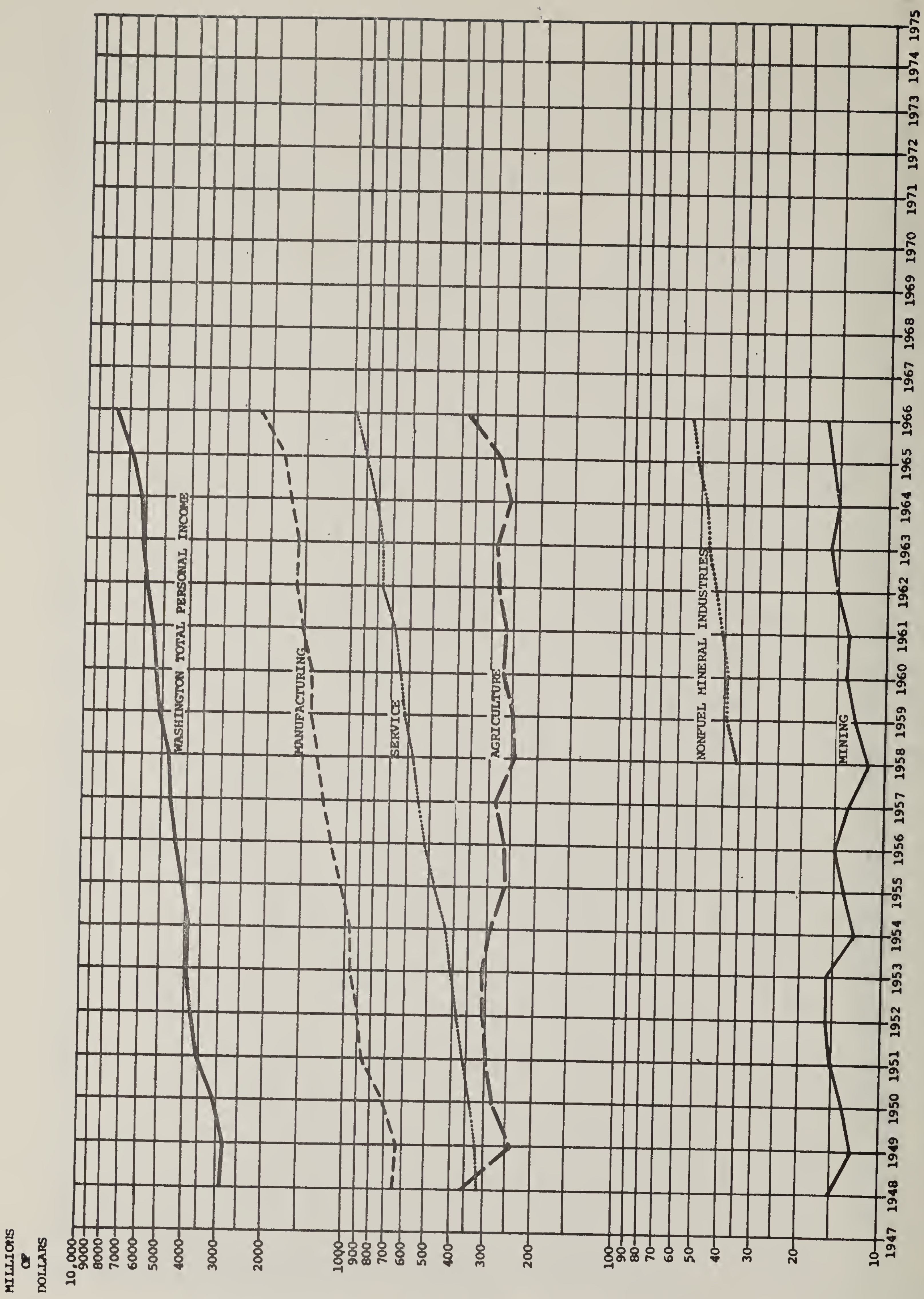


Fig. 41 - Personal income received for participation in current production in Washington.

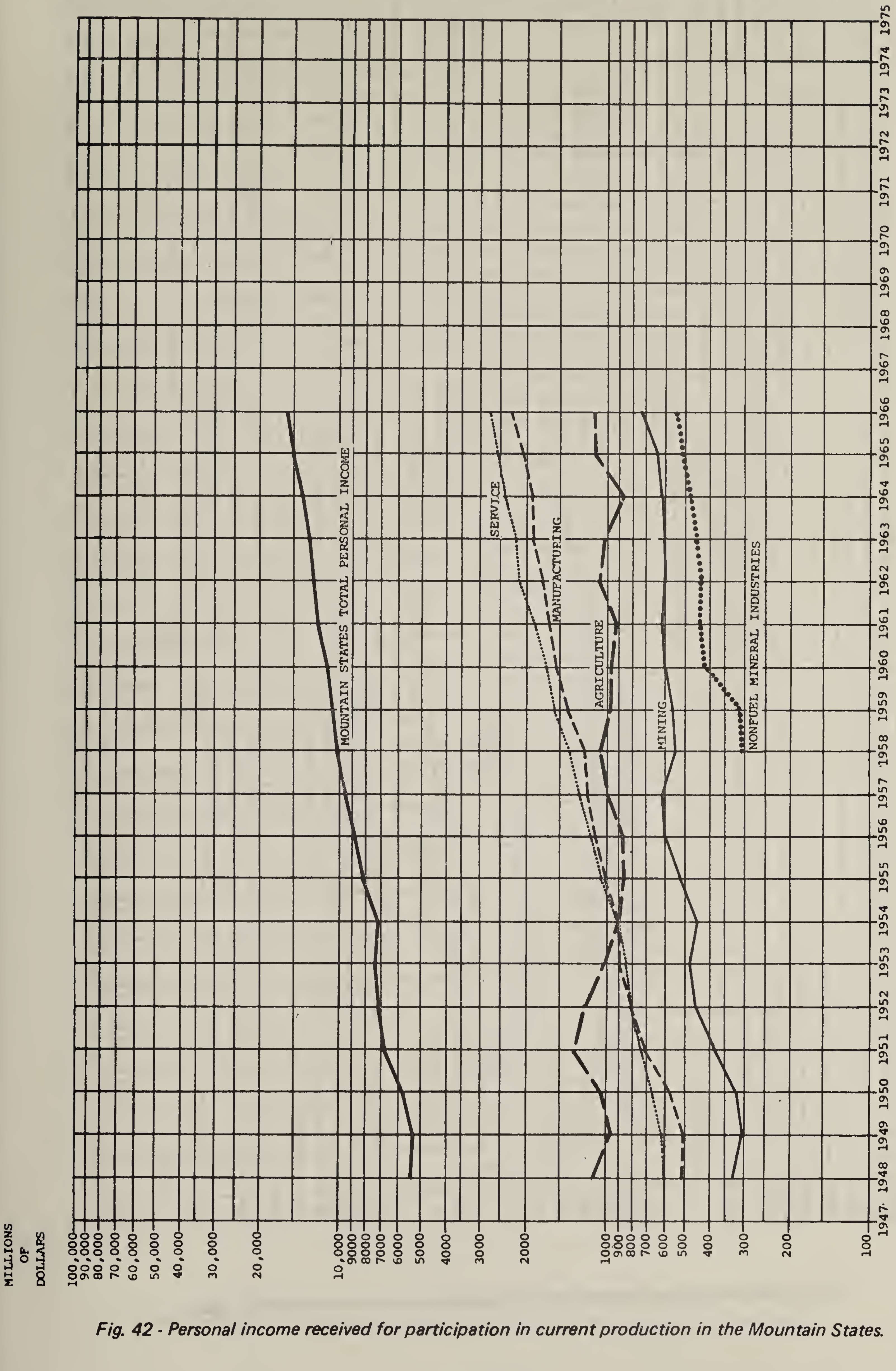


Fig. 42 - Personal income received for participation in current production in the Mountain States.

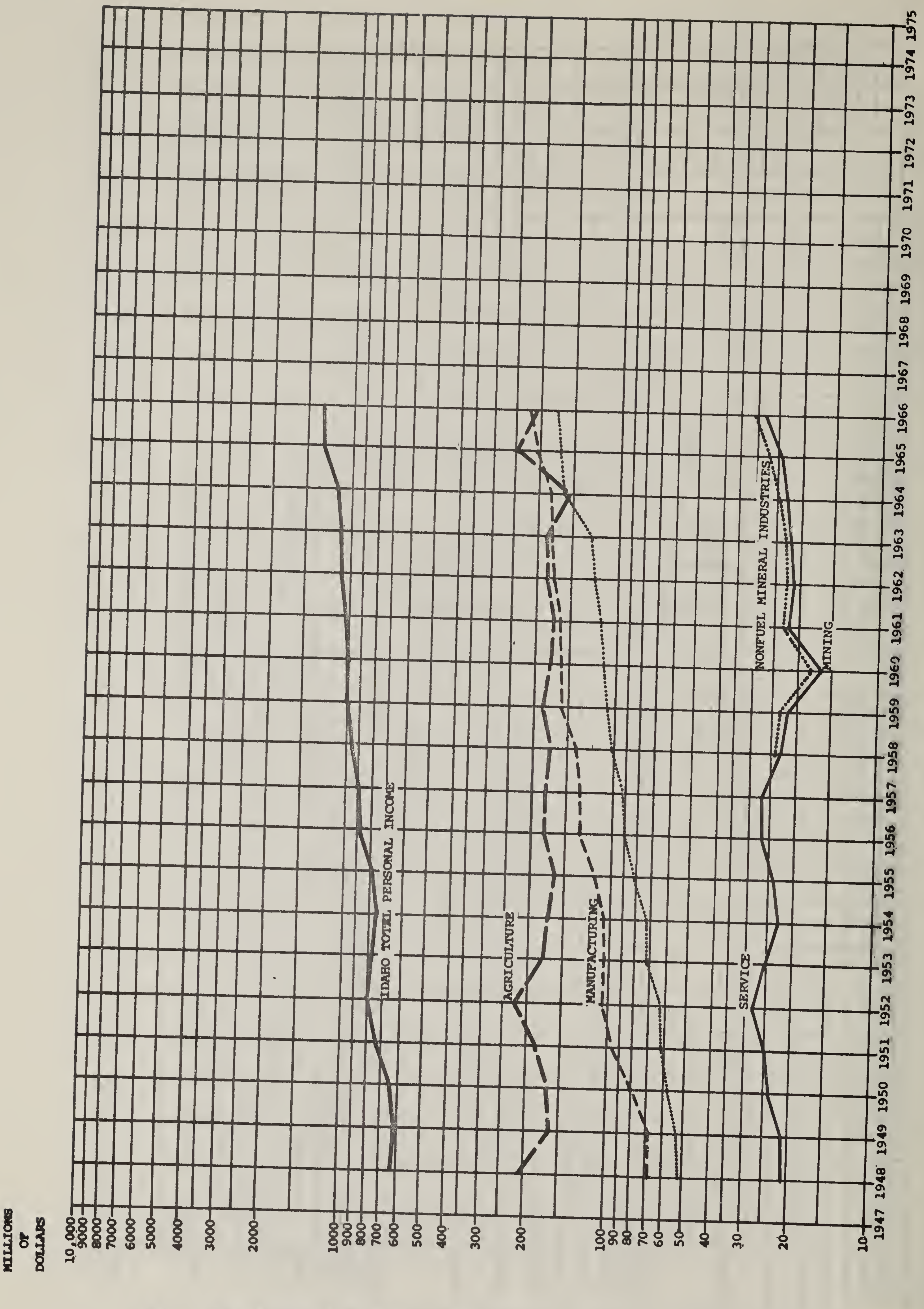


Fig. 43 - Personal income received for participation in current production in Idaho.

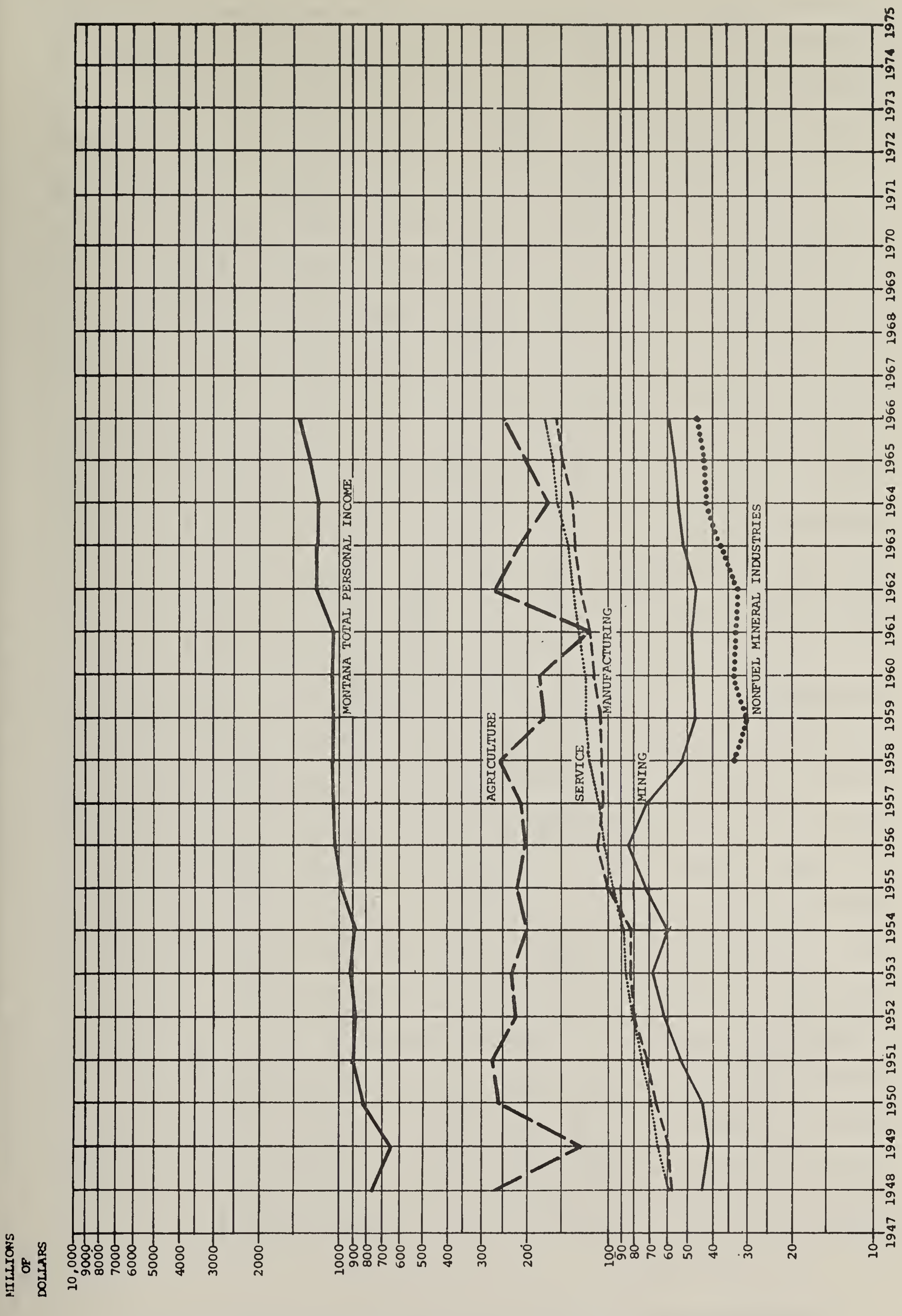


Fig. 44 - Personal income received for participation in current production in Montana.

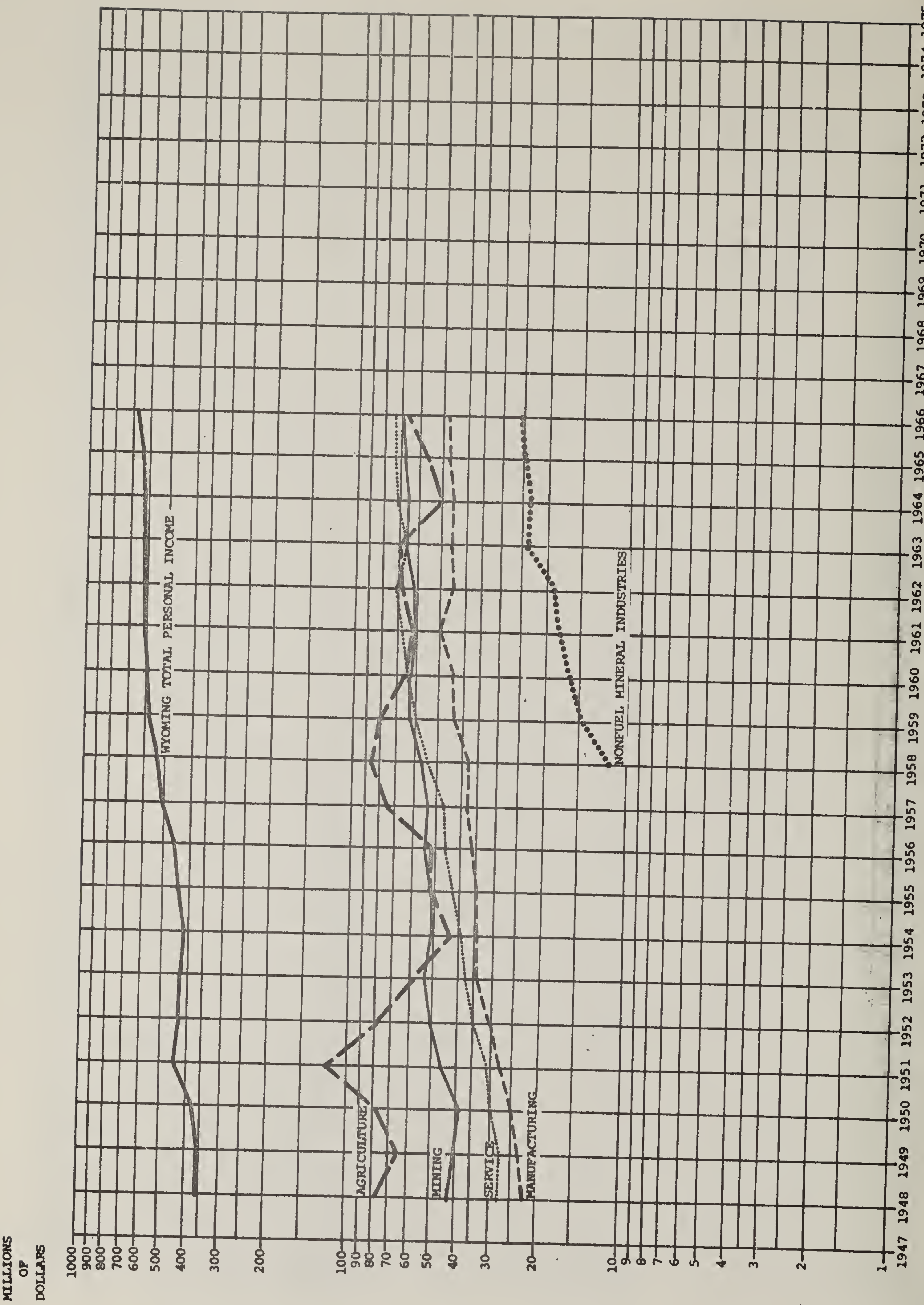


Fig. 45 - Personal income received for participation in current production in Wyoming.

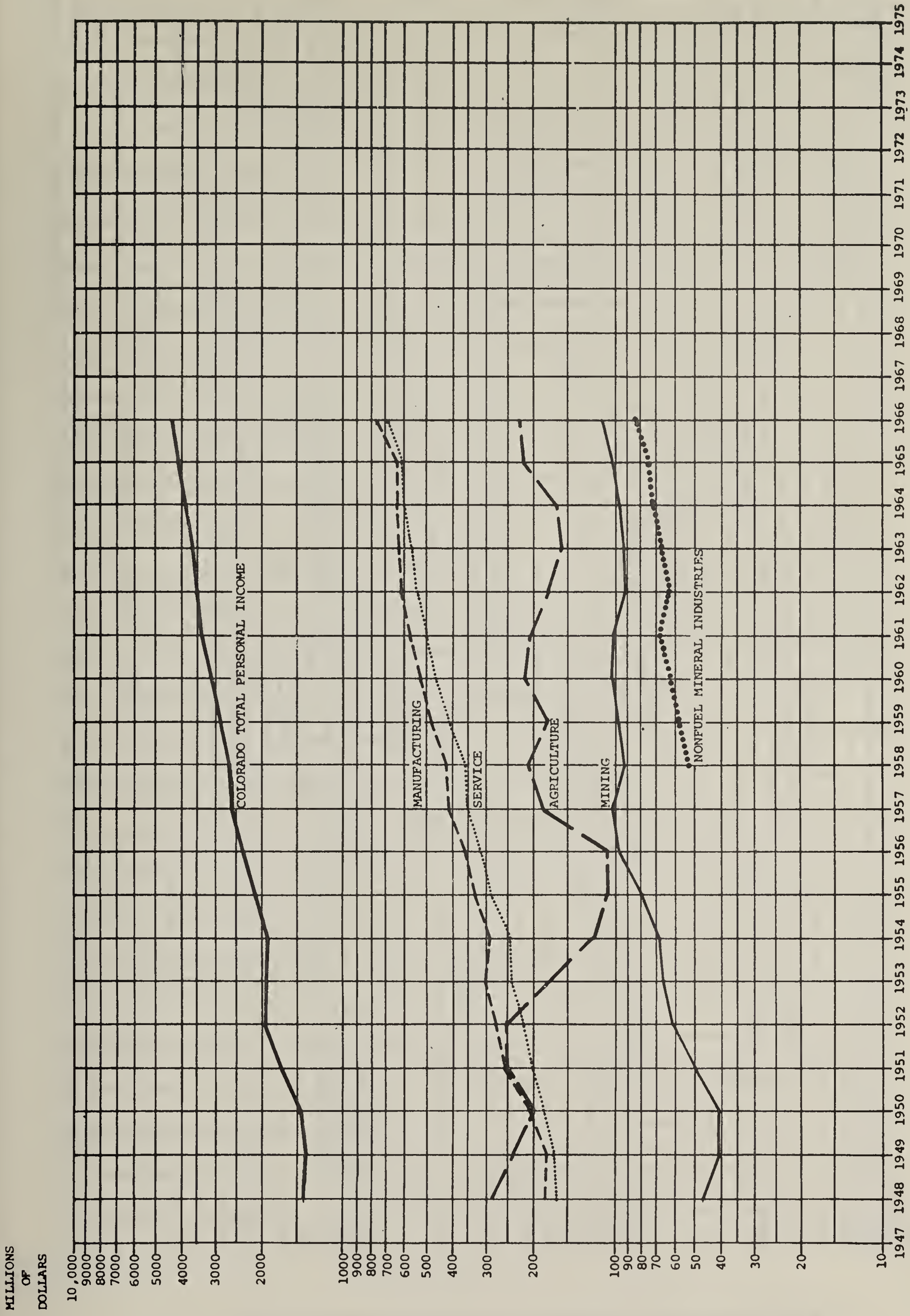


Fig. 46 - Personal income received for participation in current production in Colorado.

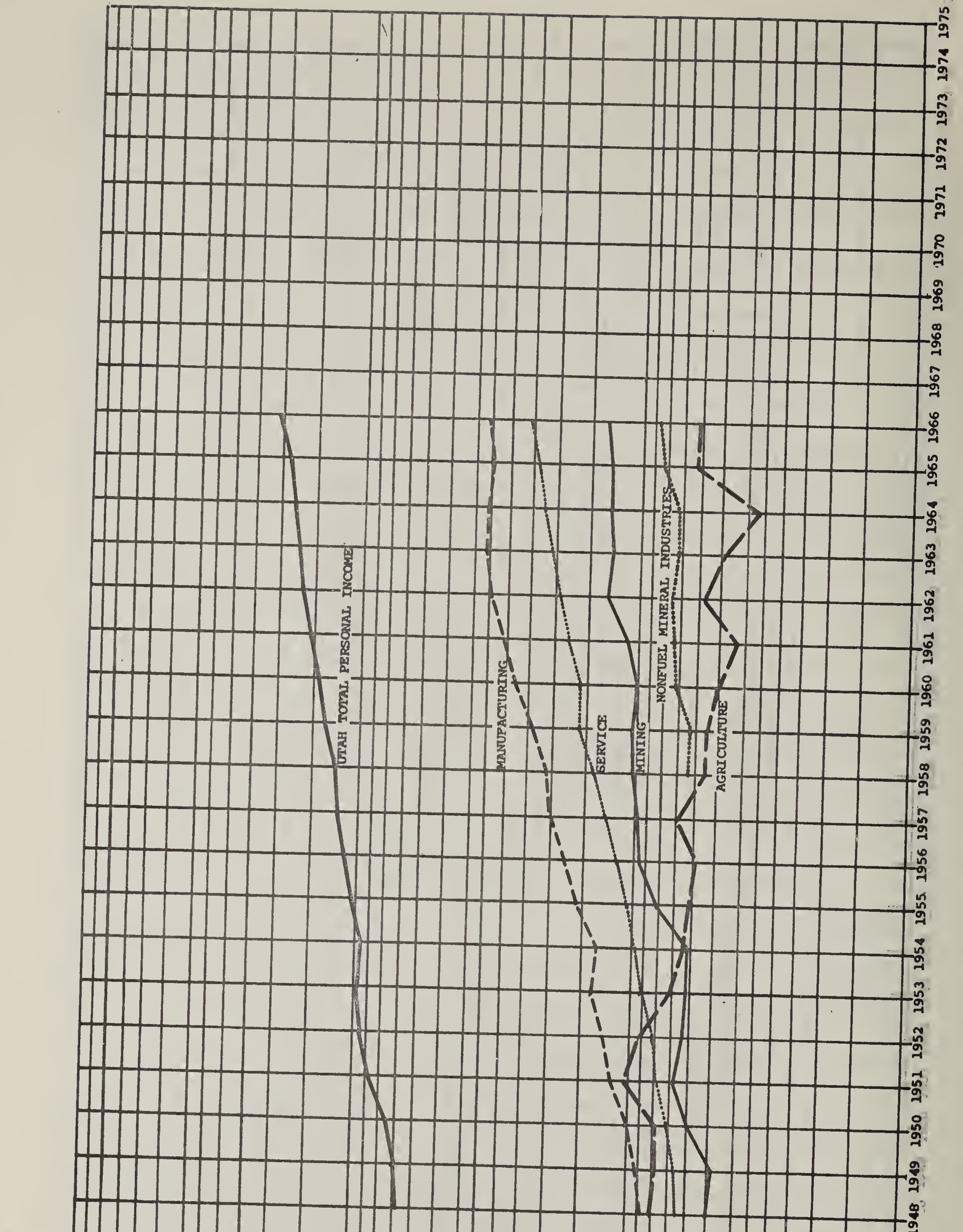


Fig. 47 - Personal income received for participation in current production in Utah.

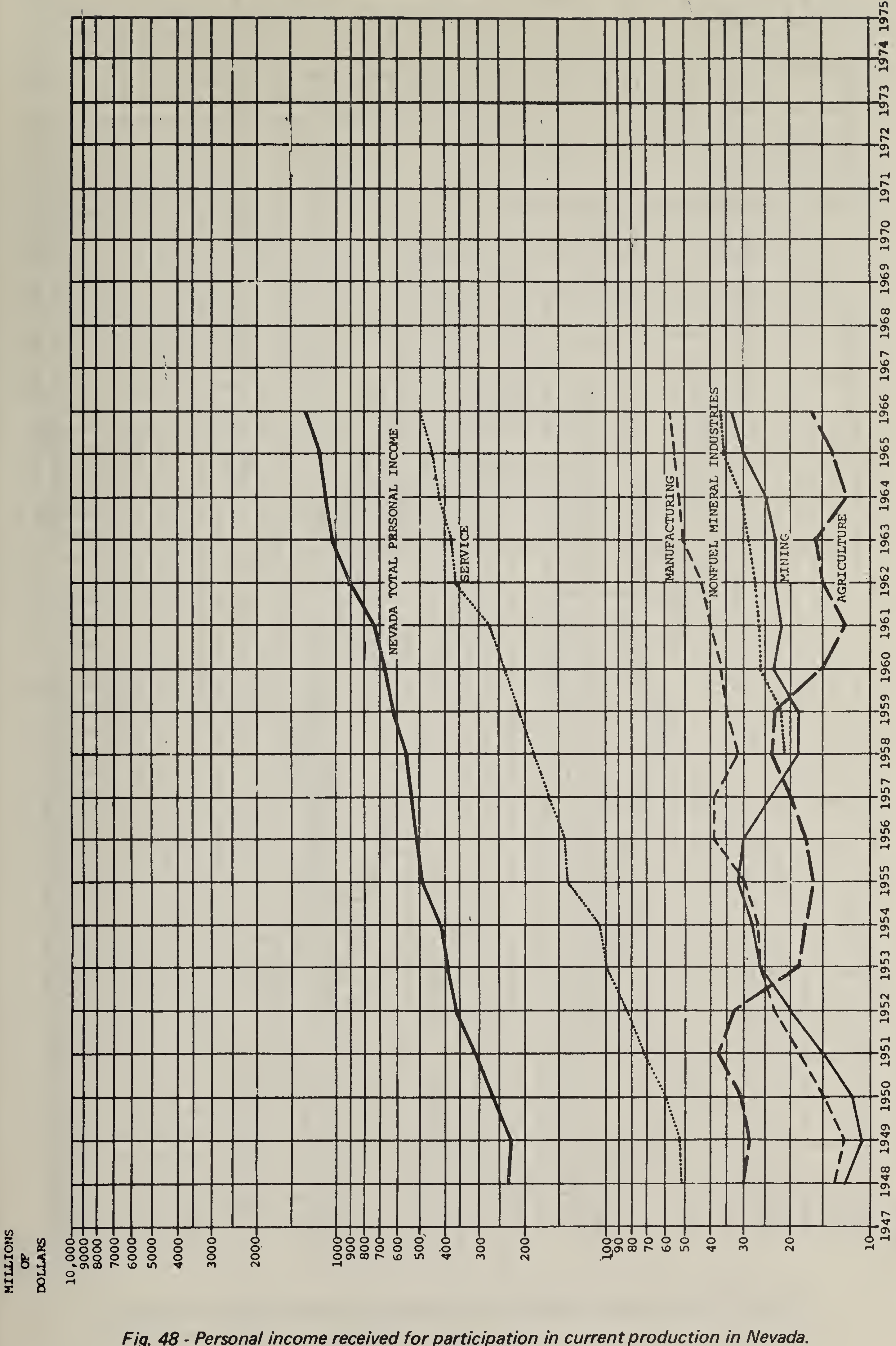


Fig. 48 - Personal income received for participation in current production in Nevada.

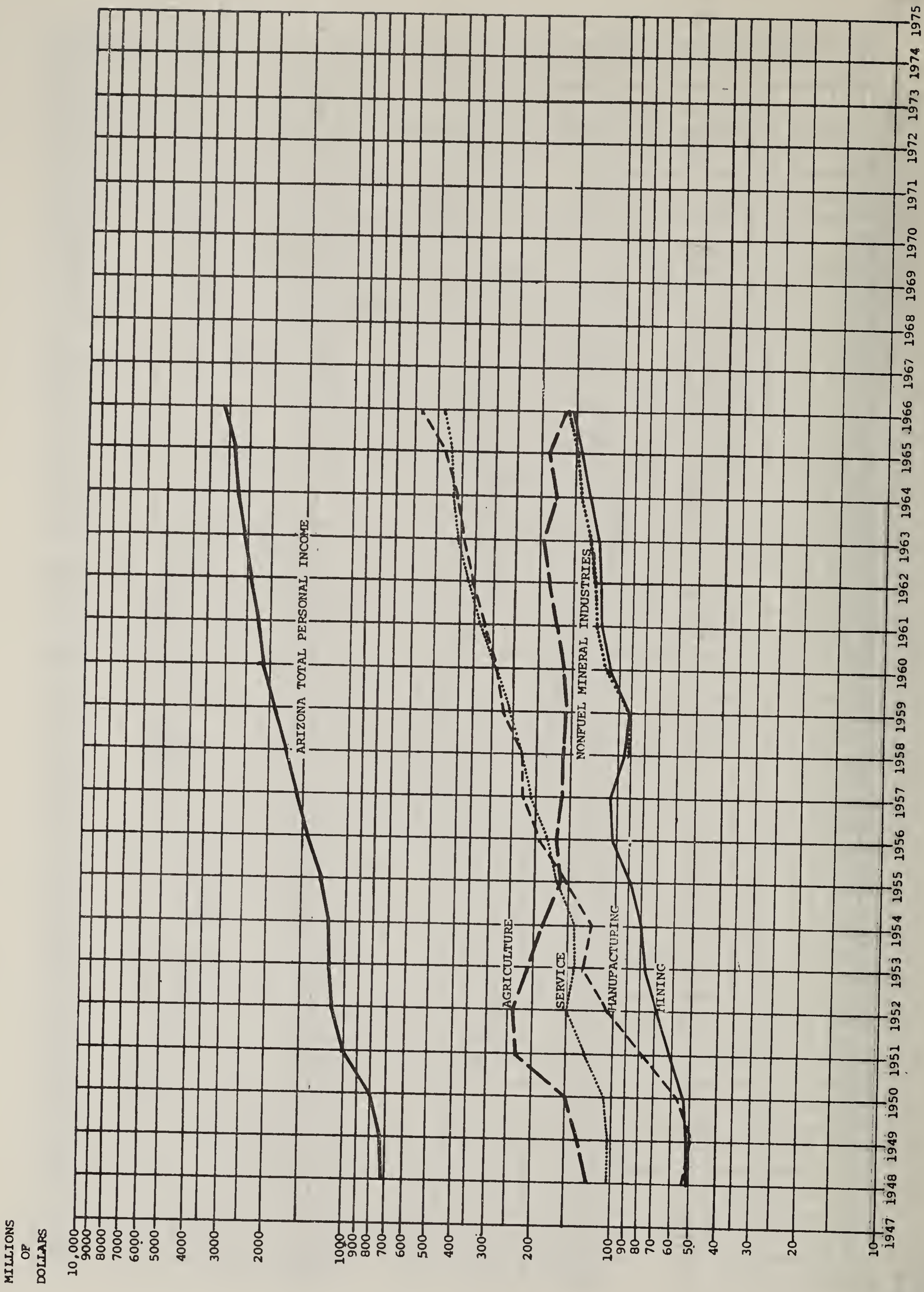


Fig. 49 - Personal income received for participation in current production in Arizona.

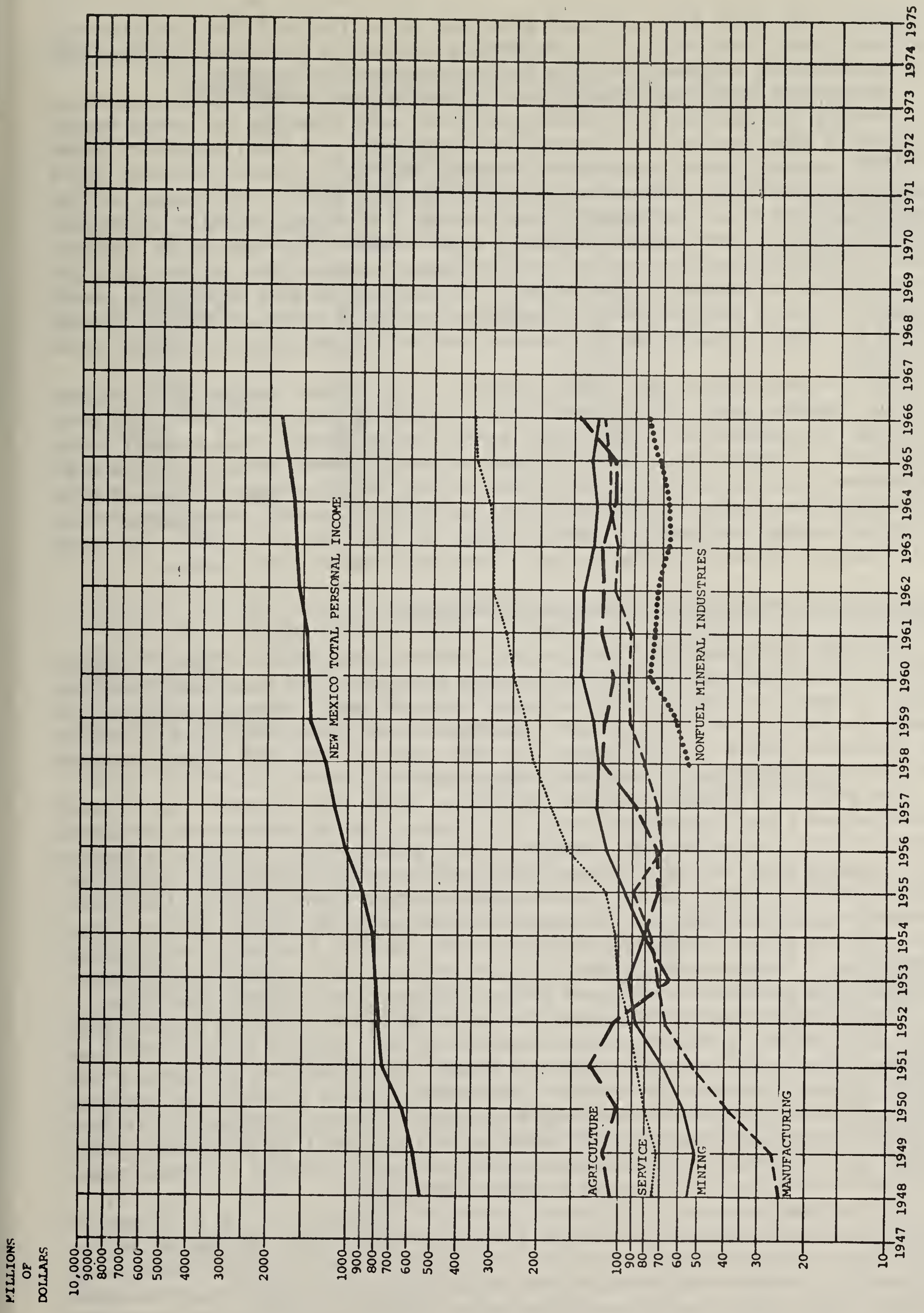


Fig. 50 - Personal income received for participation in current production in New Mexico.

businesses they would have patronized would also suffer. The total effect from one such two-week period without income for the miners would result in the loss of roughly $87,000 in business income and about $24,000 in total personal income in that state.

On the other hand, assume that a similar new mining operation were to begin operations in *Wyoming* and that the 50 newly-employed men were to receive the average weekly earnings of mine workers in that state. This would result in a direct addition of about $13,000 to earned income in any two-week period. Here again, however, multiplier effects would be encountered. These mine workers would spend most of this income, and the recipients would in turn spend most of their earnings. The outcome would be an ultimate addition of slightly more than $25,000 to the state's business income and nearly $9,000 to other personal incomes, *for each two weeks of mine operation.* Over an entire year, the direct increase in personal income caused by the initiation of such an operation would amount to almost $340,000 while the additional increase in secondary personal incomes would be about $235,000 and the resultant gain in business income would be about $650,000.

For the United States as a whole, weighted average weekly earnings in the nonfuel mineral industries were slightly lower than in all mining until 1959. After that year, however, the positions were reversed with nonfuel mineral workers being generally better paid. Both all mining and the nonfuel mineral industries received average weekly earnings higher than those prevailing in manufacuturing. Average weekly earnings in agriculture were significantly lower, indeed, they have been less than half of the weekly earnings prevalent in both the mining and nonfuel mineral sectors in every year since 1947. The same relationships are found to hold for the Pacific Coast and Mountain States regions.

4. Western Minerals and Western Economic Development

The early development of metallic mineral resources in the Western United States was one of the principal causes of the initial economic development and industrialization of the region. In many areas, the production of metals or metallic ores for shipment outside of the region was the only reason for economic development and, in fact, for settling the area at all. Economic growth in these areas thus went hand in hand with mineral resource development and the growth of the metal mining industries.

The growth of industrial minerals production in the West, however, has in most instances been a result rather than a cause of the region's overall industrial and population growth. Metallic mineral production (except for iron) primarily is still a response to demand at the national level. On the other hand, nonmetallic minerals (except for the borates and potash) primarily supply regional manufacturing and construction industries. One of the reasons for this is the high costs of shipment of most industrial minerals relative to their value. Because of the localized nature of most industrial minerals production and distribution, the economic development of the individual states and their local economies necessitates the concurrent development of nonmetallic minerals production capabilities.

The total value of nonmetallic mineral output in the 11 Western States increased from about $350 million in the late 1940's to more than $1.3 billion in the late 1960's, an increase of almost 300 percent over the two decades. This increase was not spread evenly among the states, however. The output of nonmetallic minerals increased most rapidly in Oregon, Wyoming, and New Mexico, rising from around $20 million to almost $110 million in Oregon, from $12 million to over $60 million in Wyoming, and from $30 million to $155 million in New Mexico. Industrial mineral output increased the slowest in Arizona, where the 1966 total was less than 50 percent above the 1949 figure.

Not only were there large differences from state to state in the *rate* of increase of industrial minerals outputs, but there were even greater differences in the *levels* of outputs. As might be expected, California led the Western States in the total production of nonmetallic minerals in both 1949 and 1966. In fact, California's output was equal to the combined output of the next six states in both years. Nevada and Wyoming had the smallest

Table 1

ECONOMIC INCOME MULTIPLIERS FOR THE WESTERN STATES[a]

State	Additional Income Generated by an Increase of $100 of Personal Income		Duration of Effect (Number of Time Periods)
	Added Business Income	Added Personal Income	
1. California	$816.15	$213.32	119
2. Washington	618.97	172.62	79
3. Oregon	530.76	150.12	70
4. Colorado	521.76	139.67	70
5. Arizona	452.52	108.13	60
6. New Mexico	400.09	97.50	52
7. Utah	366.55	86.97	47
8. Idaho	304.70	77.94	40
9. Montana	300.62	80.13	40
10. Nevada	264.70	63.29	34
11. Wyoming	261.20	65.69	34

[a]This table shows in descending order the additional personal income and the additional business income generated from $100 of added personal income, and the number of two-week time periods it takes for this income to be produced for each of the eleven Western States.

See Appendix N for the derivation methodology.

Source: Division of Economic and Business Research, The University of Arizona.

industrial minerals industries at the end of World War II, but both increased their production of these commodities quite rapidly.

The output of nonmetallic minerals in any given year has been closely related to manufacturing output in most of the individual Western States. Table 2 contains the correlation coefficients between nonmetallic mineral output and value added in manufacturing for each state from 1949 to 1966, the years for which comparable data are available. The correlation coefficients are extremely high in all the states except New Mexico. These coefficients exceed .90 in eight of the states and .80 in two of the remaining three. A correlation coefficient of .99 such as was obtained for California indicates that over the 1949 to 1965 period, 98 percent ($.99^2$) of the variation in California's industrial minerals production was directly associated with variation in the state's manufacturing output. The correlation coefficient of .66 observed for New Mexico, however, indicates that only about 44 percent ($.66^2$) of the variation in industrial minerals output was directly associated with changes in manufacturing activity.

The high correlation coefficients, however, must be interpreted with extreme caution. They merely express a statistical relationship, an association, and not a causal relationship. Actually, industrial minerals are used directly as raw materials inputs in only a few manufacturing industries (e.g., chemicals, stone and glass products, and primary metal products). These industries contribute only a relatively small percentage (from six to 33 percent)[18] of total manufacturing output in most of the Western States. But they are

Table 2

CORRELATION COEFFICIENTS BETWEEN NONMETALLIC MINERAL PRODUCTION AND VALUE ADDED IN MANUFACTURING

(by state, 1949-1966)

State	Correlation Coefficient	Associated Variation (Percent)
California	.99	98
Washington	.97	94
Oregon	.95	90
Nevada	.95	90
Wyoming	.95	90
Utah	.94	88
Montana	.94	88
Colorado	.91[a]	83
Arizona	.89	79
Idaho	.80	64
New Mexico	.66	44

[a] Colorado experienced a major change in the classification of minerals reported in 1960, so that the 1960 and later income figures for nonmetallic mineral output are not comparable with earlier years.

Source of data: Appendix O.

Table 3

CORRELATION COEFFICIENTS BETWEEN NONMETALLIC MINERAL PRODUCTION AND VALUE OF CONSTRUCTION CONTRACTS

(by state, 1959-1966)

State	Correlation Coefficient	Associated Variation (Percent)
Idaho	.89	79
California	.83	69
Oregon	.79	62
New Mexico	.76	58
Washington	.75	56
Montana	.56	31
Arizona	.55	30
Colorado	.52	27
Wyoming	.43	18
Nevada	.40	16
Utah	.37	14

Source of data: Calculated from basic data in Appendix O.

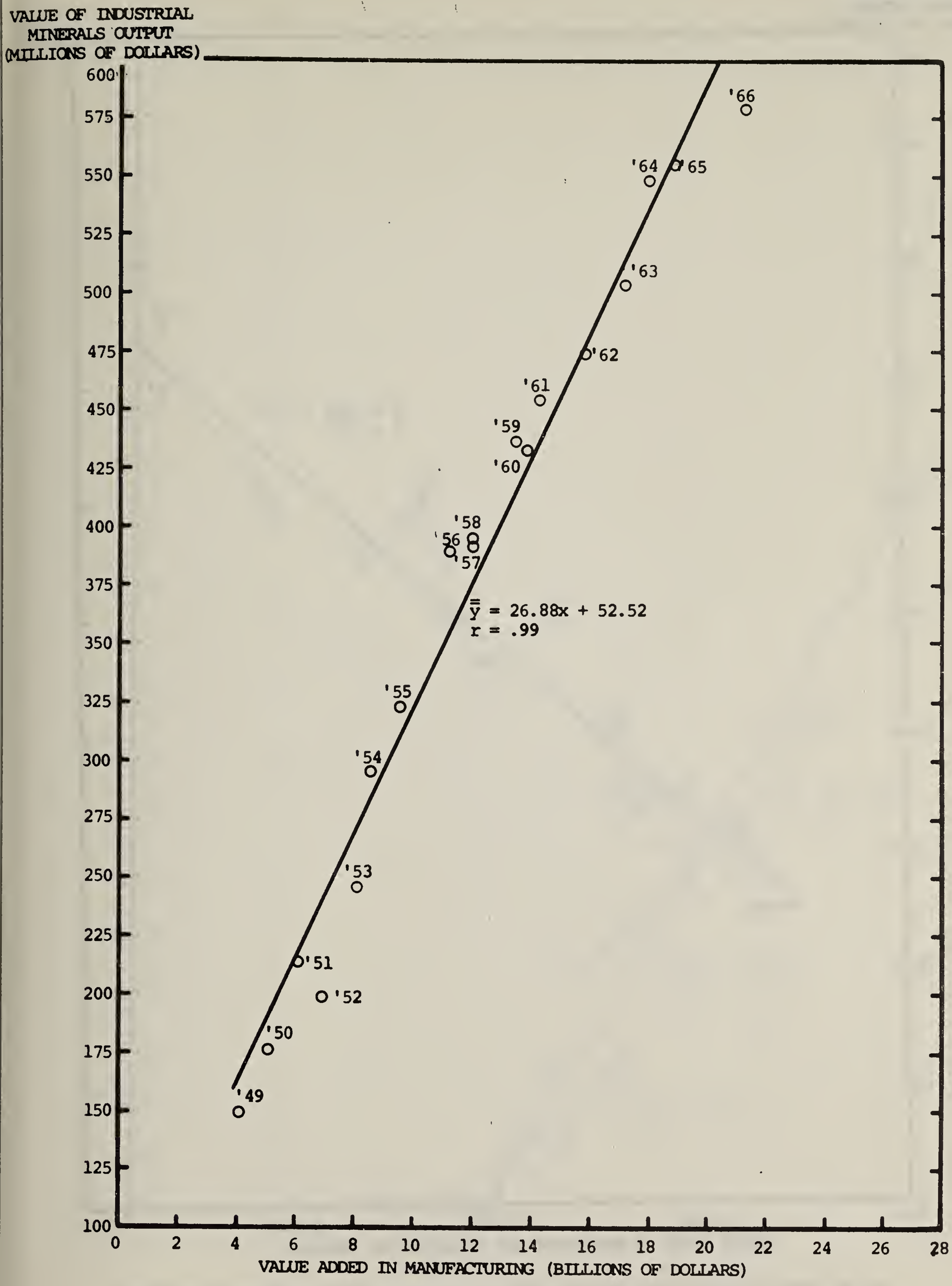


Fig. 51 - Manufacturing activity and industrial minerals production in California, 1949-1966.

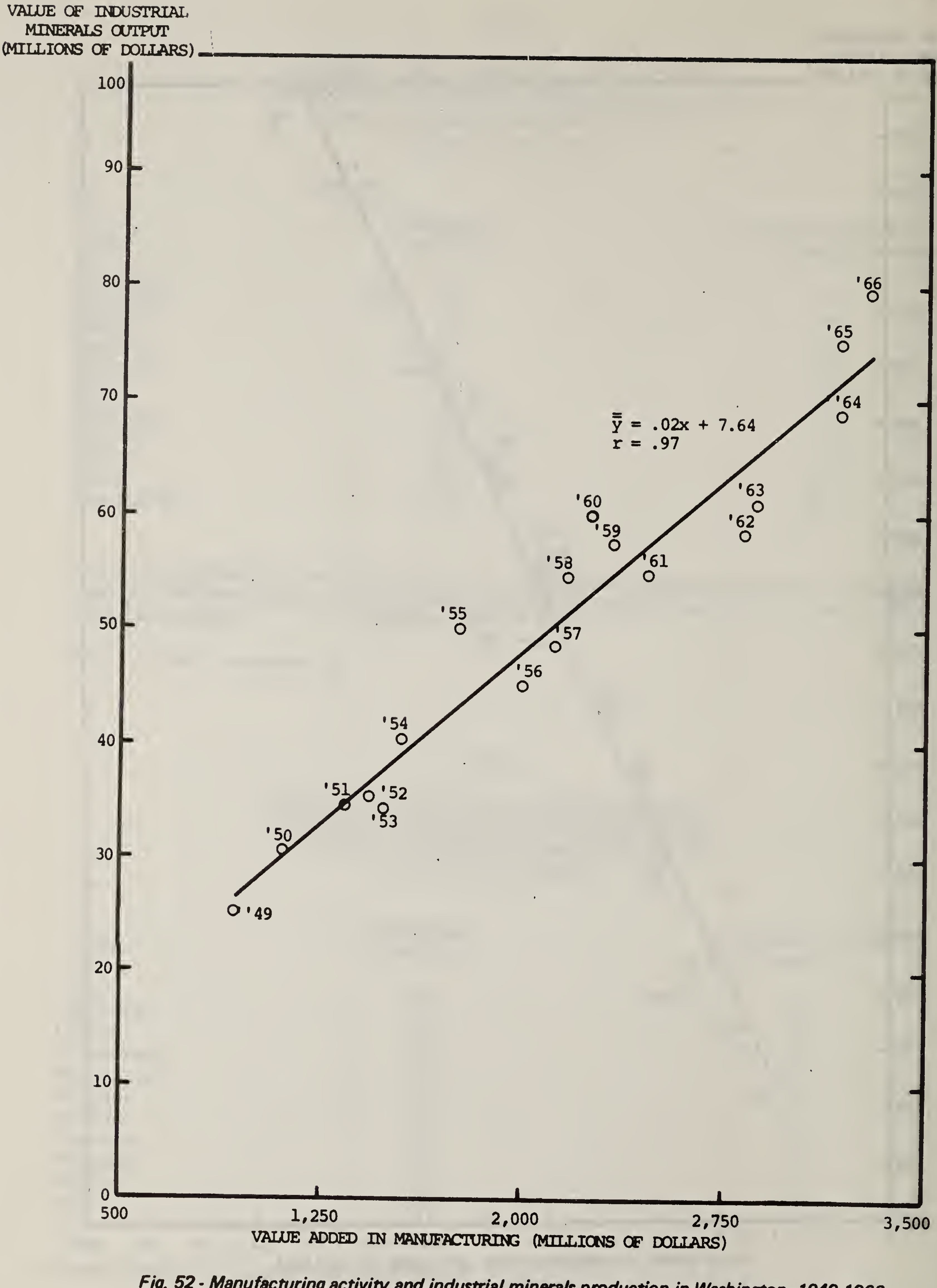


Fig. 52 - Manufacturing activity and industrial minerals production in Washington, 1949-1966.

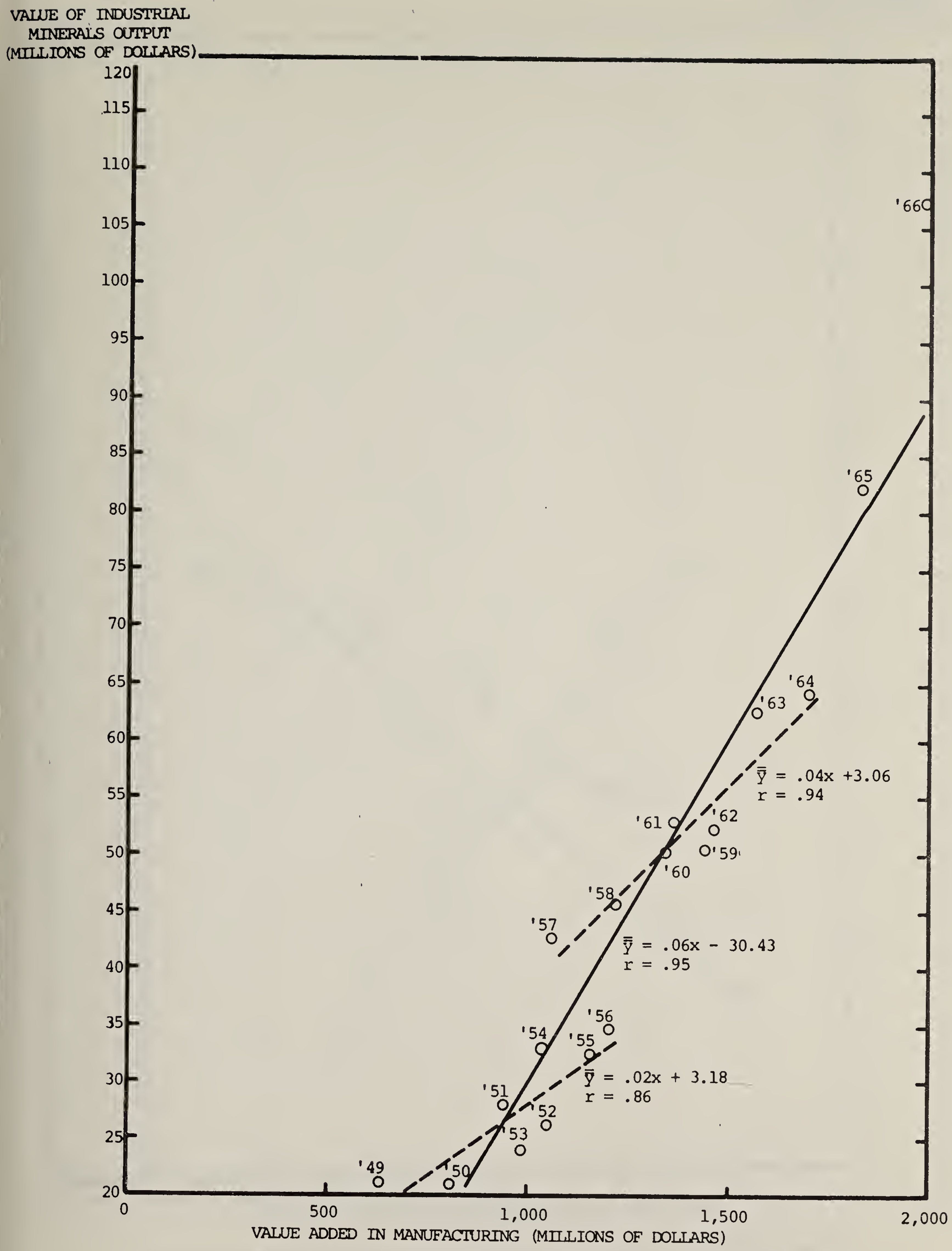


Fig. 53 - Manufacturing activity and industrial minerals production in Oregon, 1949-1966.

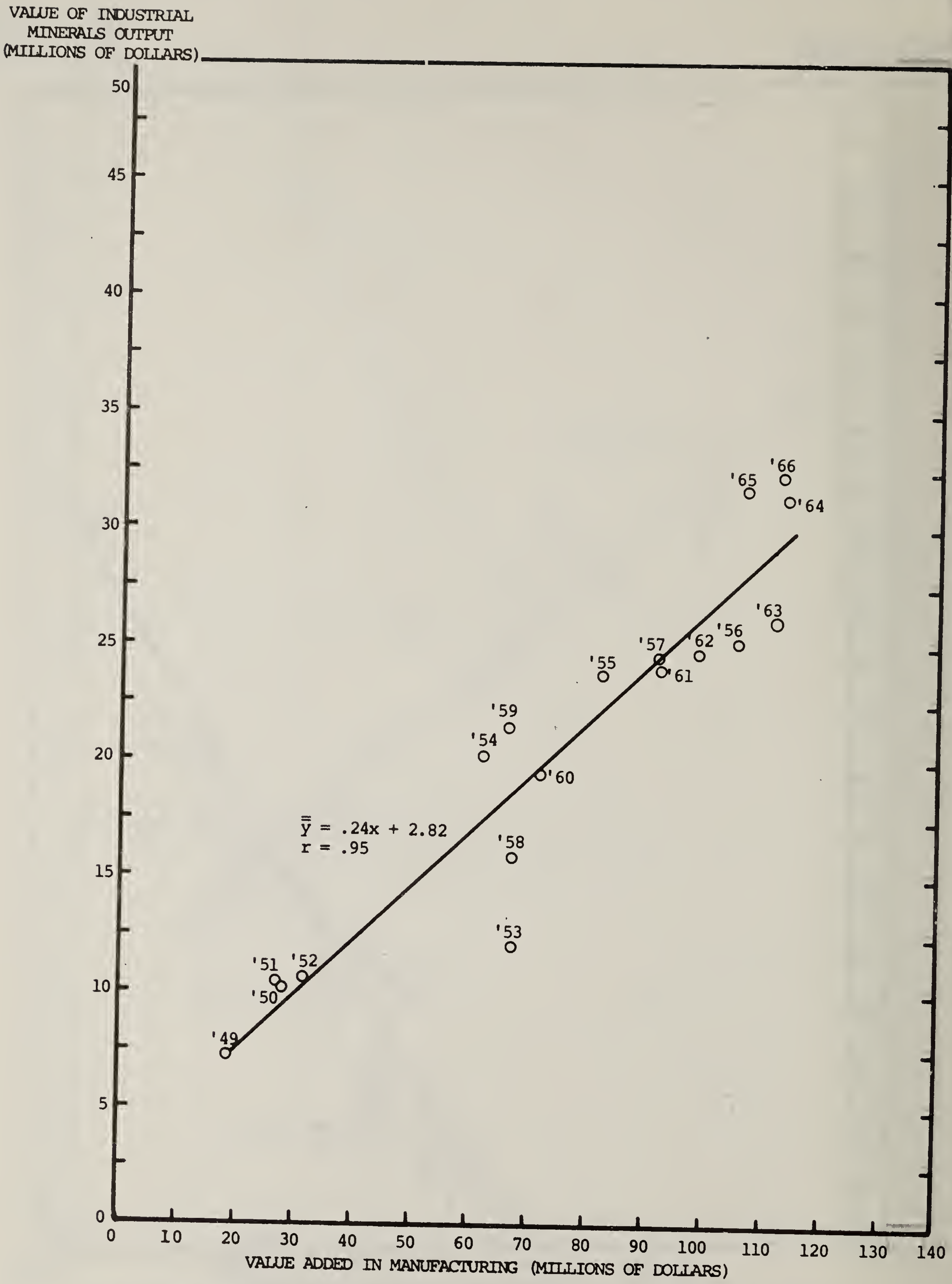


Fig. 54 - Manufacturing activity and industrial minerals production in Nevada, 1949-1966.

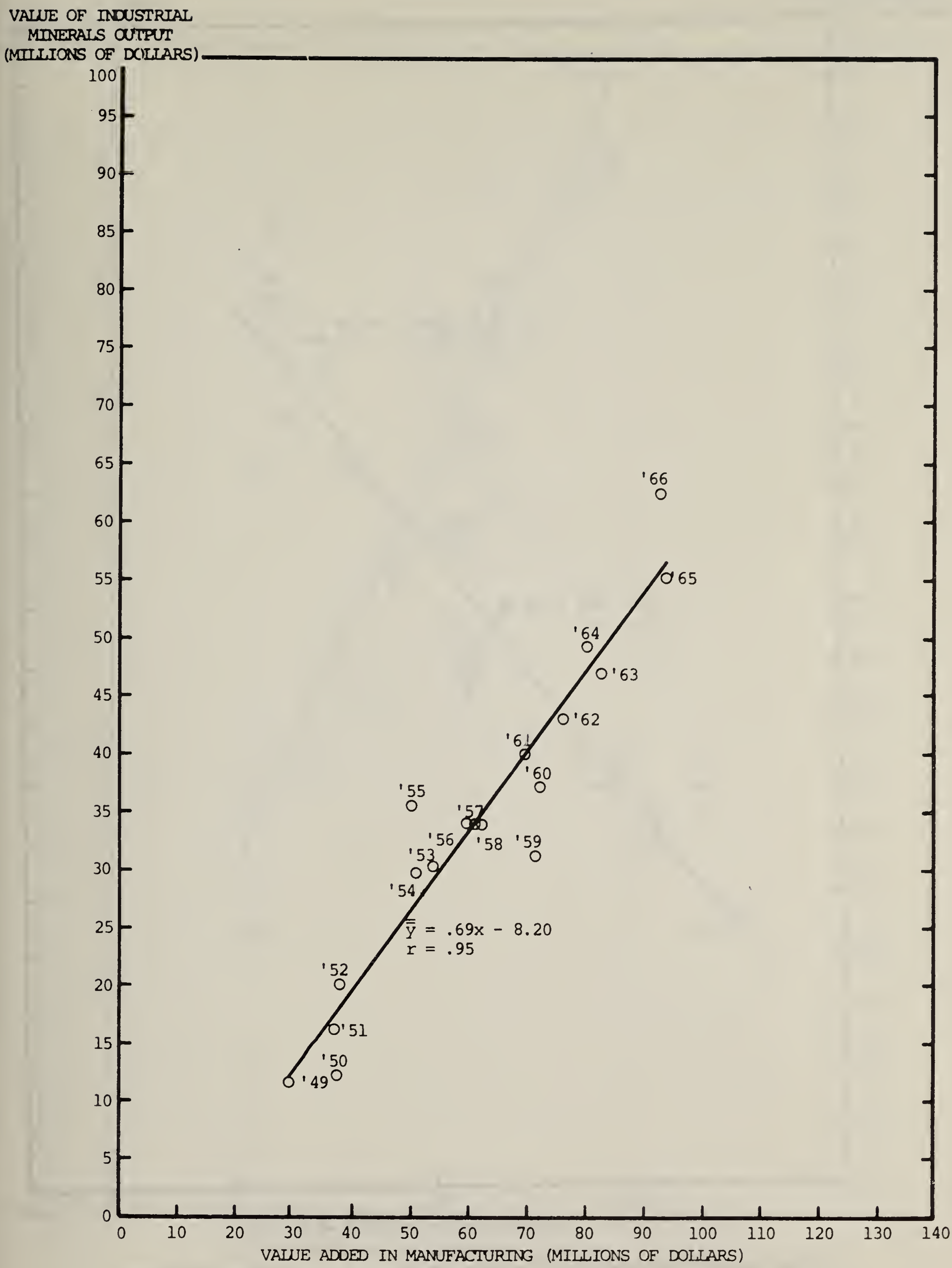


Fig. 55 - Manufacturing activity and industrial minerals production in Wyoming, 1949-1966.

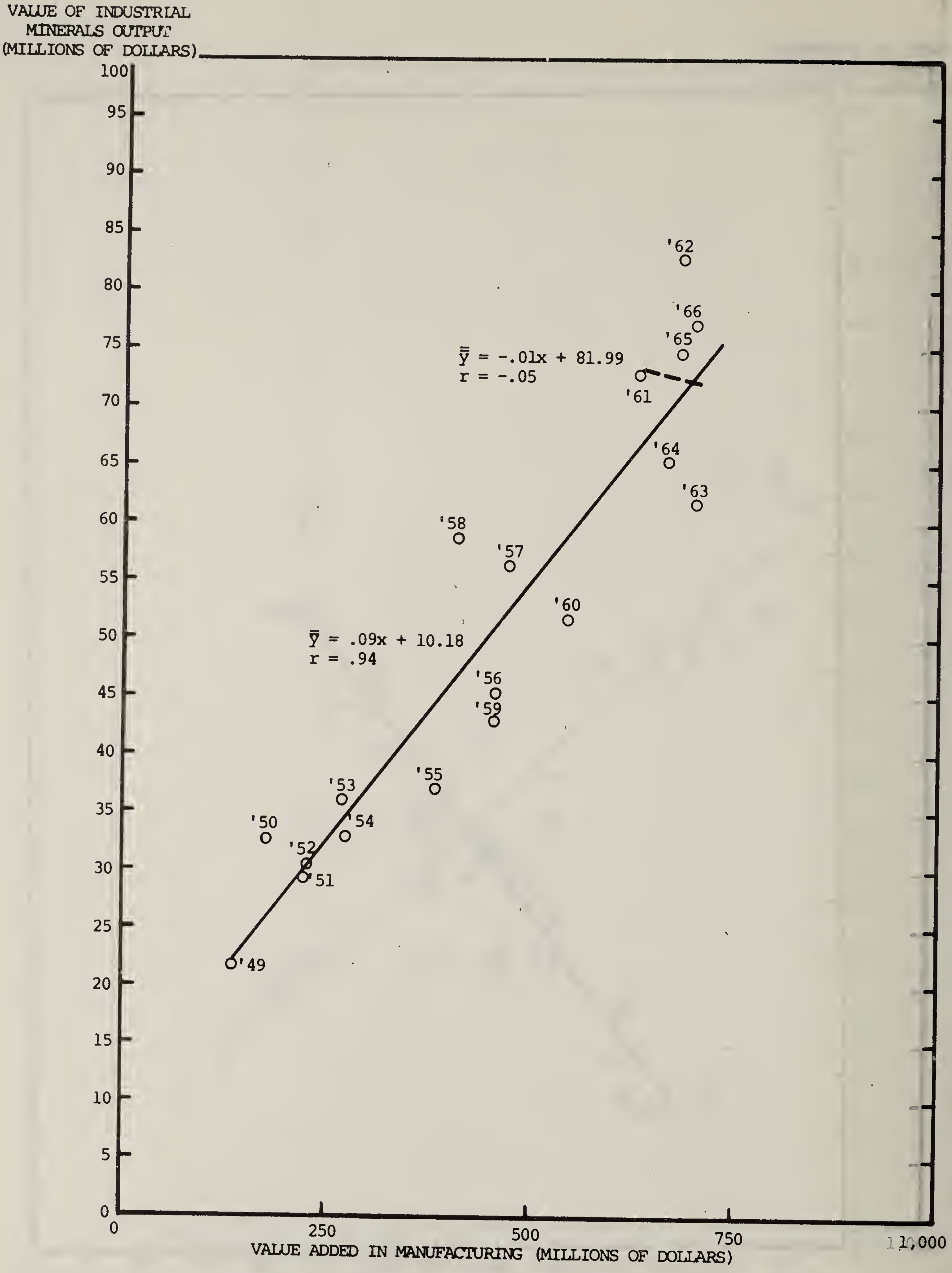


Fig. 56 - Manufacturing activity and industrial minerals production in Utah, 1949-1966.

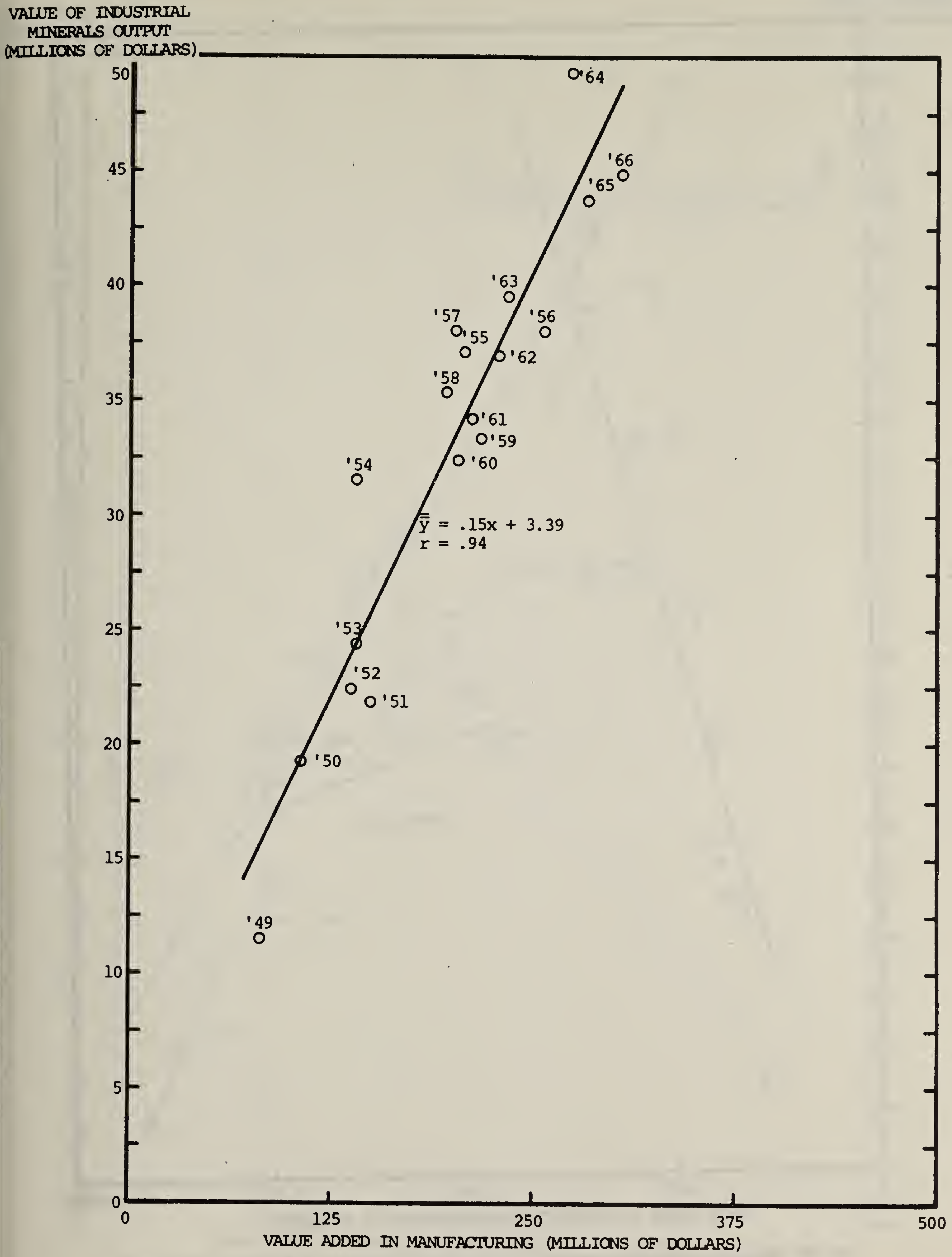


Fig. 57 - Manufacturing activity and industrial minerals production in Montana, 1949-1966.

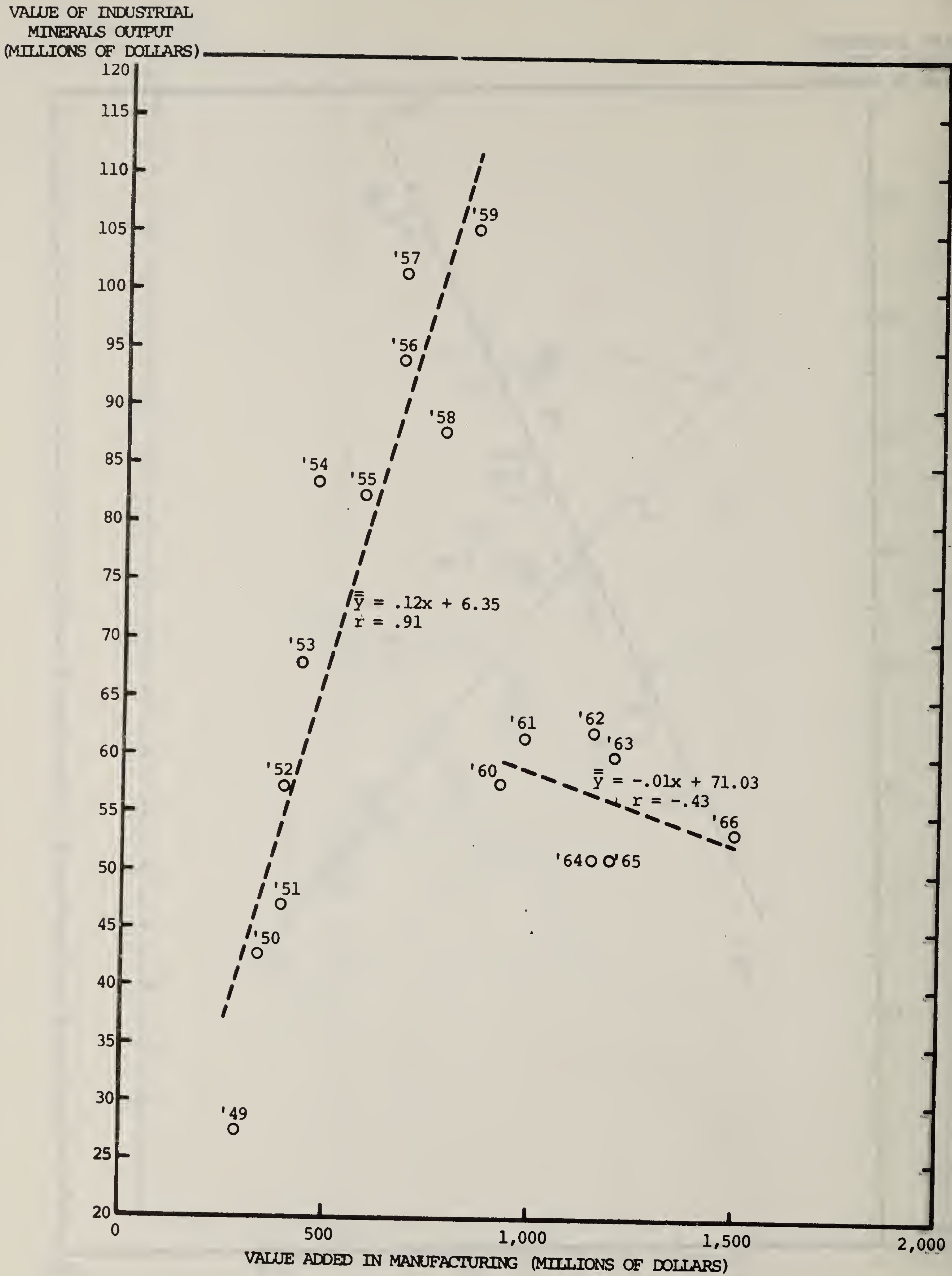


Fig. 58 - Manufacturing activity and industrial minerals production in Colorado, 1949-1966.

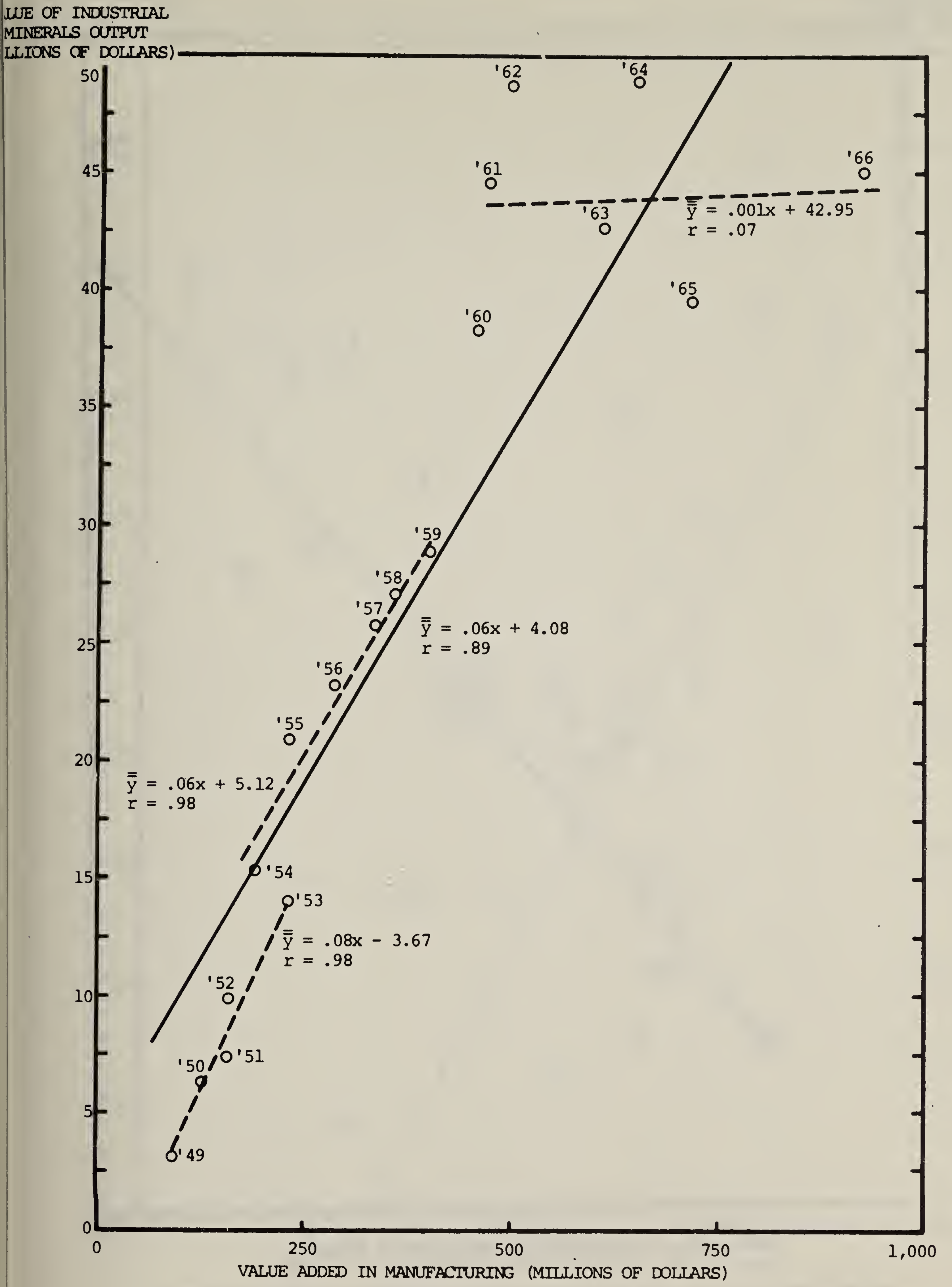


Fig. 59 - Manufacturing activity and industrial minerals production in Arizona, 1949-1966.

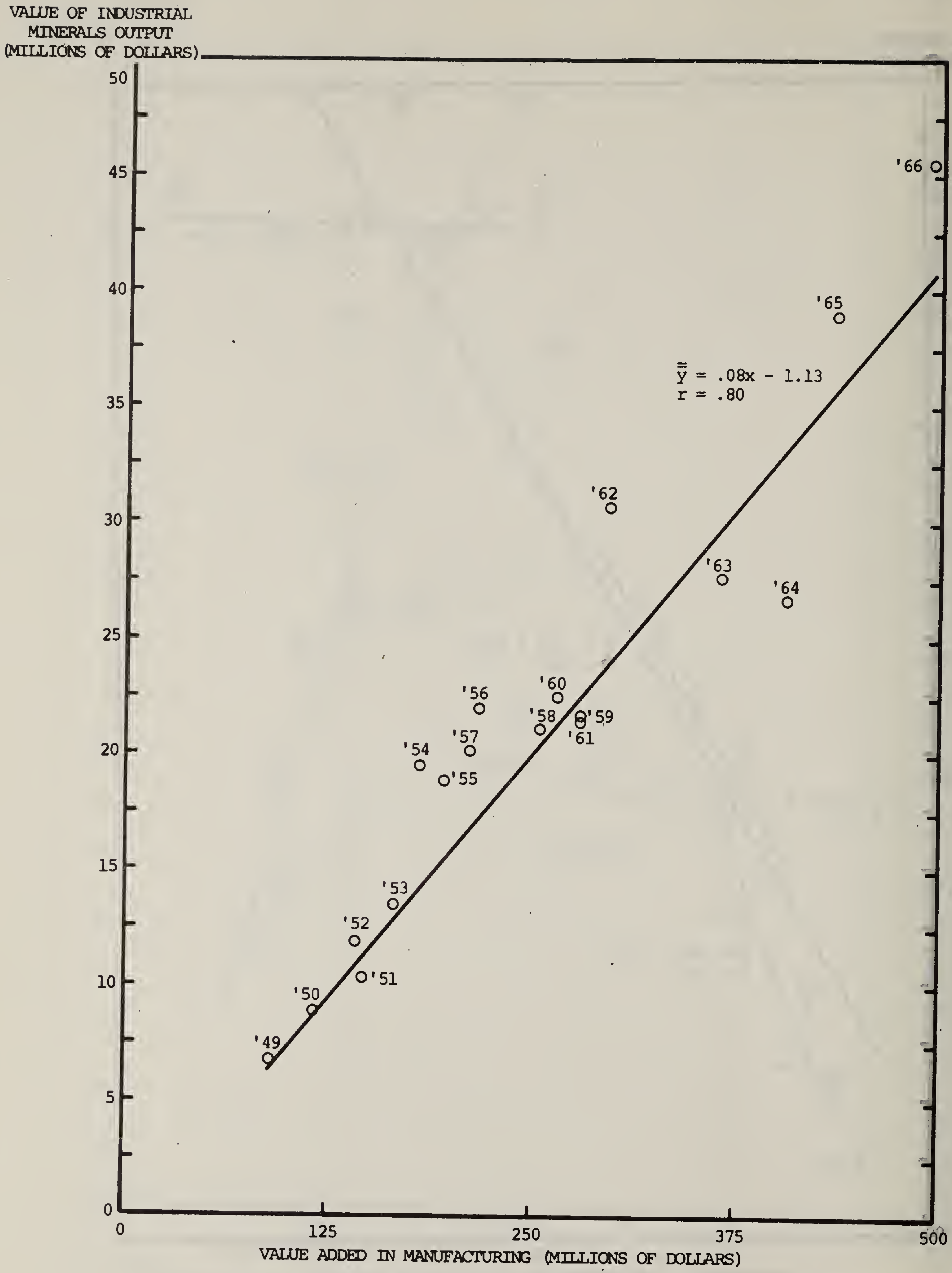


Fig. 60 - Manufacturing activity and industrial minerals production in Idaho, 1949-1966.

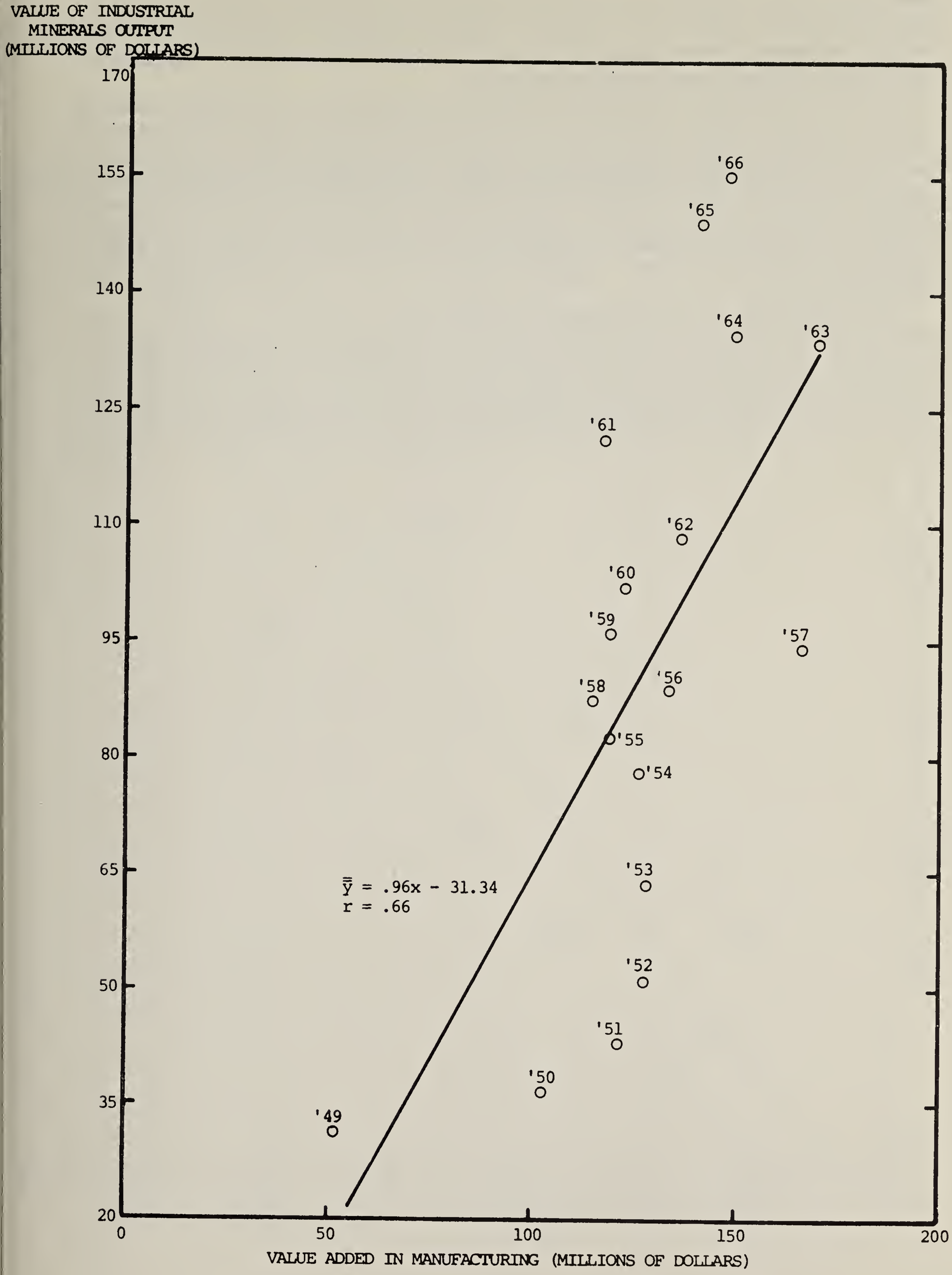


Fig. 61 - Manufacturing activity and industrial minerals production in New Mexico, 1949-1966.

widely used in the construction of manufacturing facilities. Since the statistical relationship between industrial minerals output and value added in manufacturing has been fairly close, however, estimates of future demands for nonmetallic mineral output may be predicted in fairly close accord with manufacturing projections.

Even though industrial minerals are used more in construction than in manufacturing, the statistical relationships between nonmetallic mineral output and construction activity in the various Western States have not been as close as in the instance of nonmetallic mineral output and value added in manufacturing. Table 3 contains these correlations, none of which exceeds .90. Only in California and Idaho does the coefficient exceed .80. The reason for this is probably that construction activity is high volatile. Increases and decreases of 20 percent in construction contracts in successive years have not been uncommon in many of the Western States. This highly variable behavior has not been characteristic of the manufacturing sector.

Even though many of the nonmetallic minerals such as cement, clay, gypsum, perlite, pumice, sand and gravel, and stone have their prime markets in the construction industry, nonmetallic minerals output is not as cyclical as in construction activity. This is principally because manufacturing and, to a certain extent, agriculture and other mining industries offer alternative outlets for the nonmetallics commodities and tend to stabilize demand for them as a group. The relationships in each of the various states are shown in Figures 62 through 72.

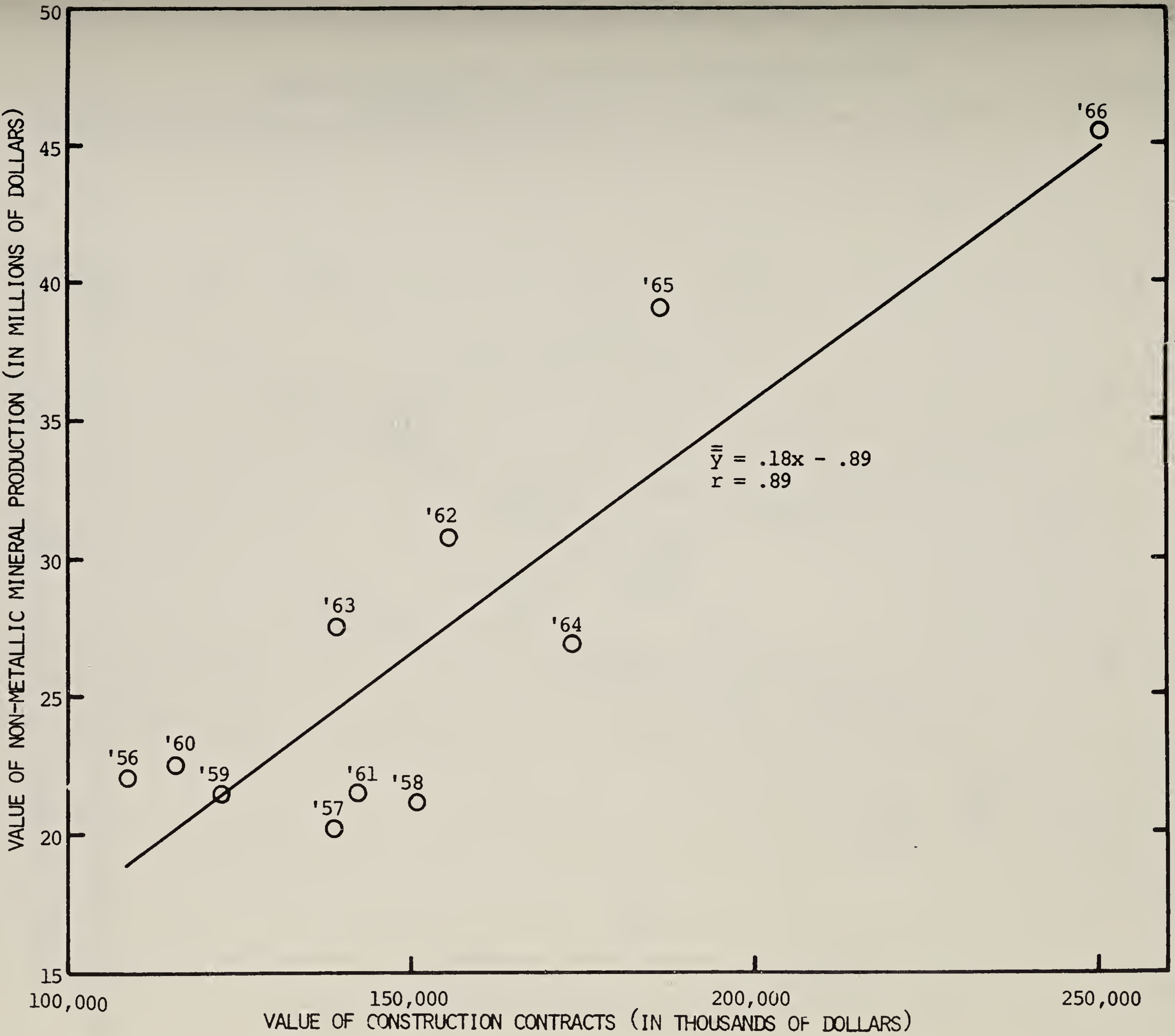
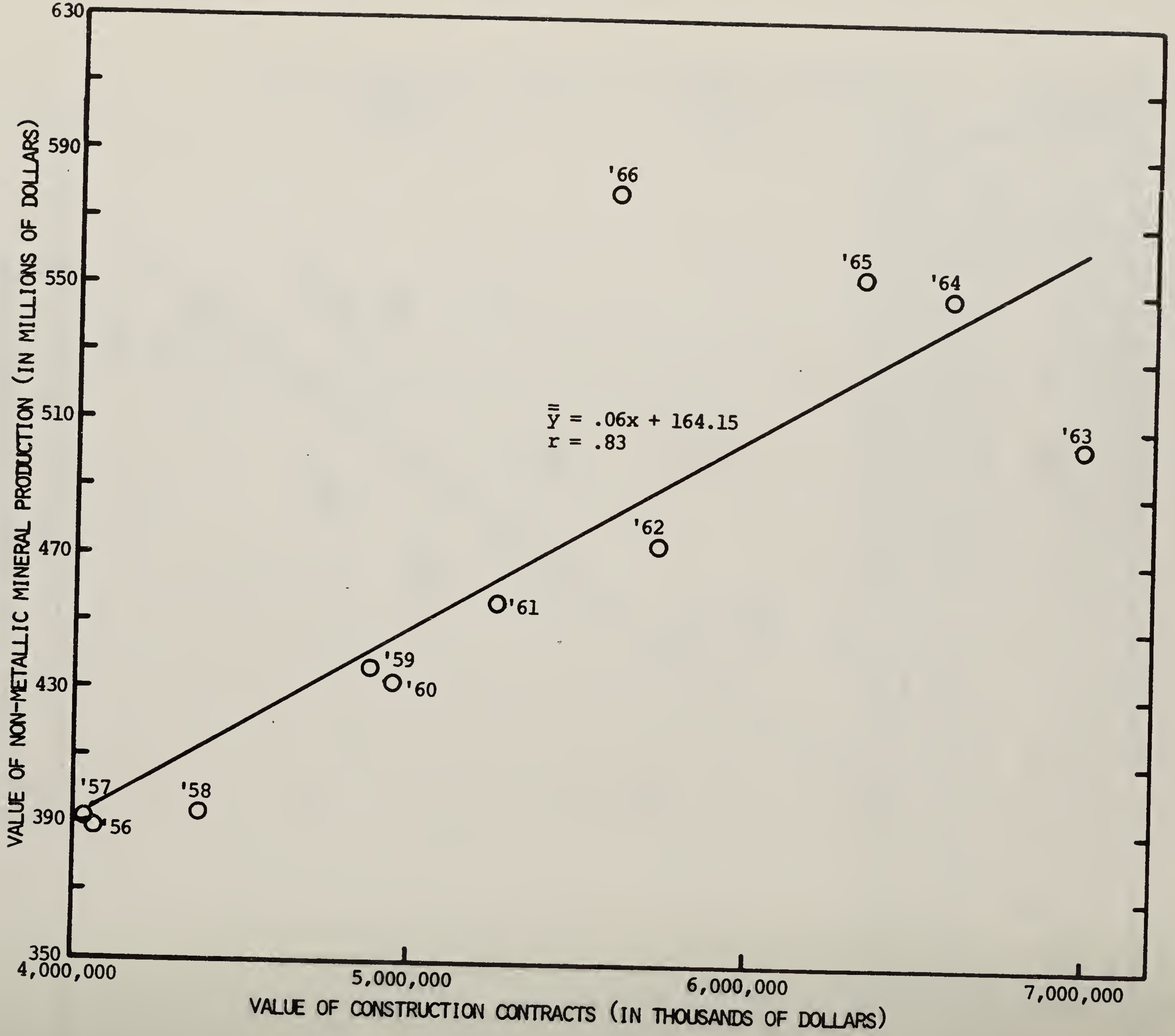


Fig. 62 - Construction activity and industrial minerals production in Idaho, 1956-1966.


630
590
550
510
470
430
390
350
4,000,000
5,000,000
6,000,000
7,000,000
VALUE OF NON-METALLIC MINERAL PRODUCTION (IN MILLIONS OF DOLLARS)
VALUE OF CONSTRUCTION CONTRACTS (IN THOUSANDS OF DOLLARS)
'56
'57
'58
'59
'60
'61
'62
'63
'64
'65
'66
$\bar{\bar{y}}$ = .06x + 164.15
r = .83

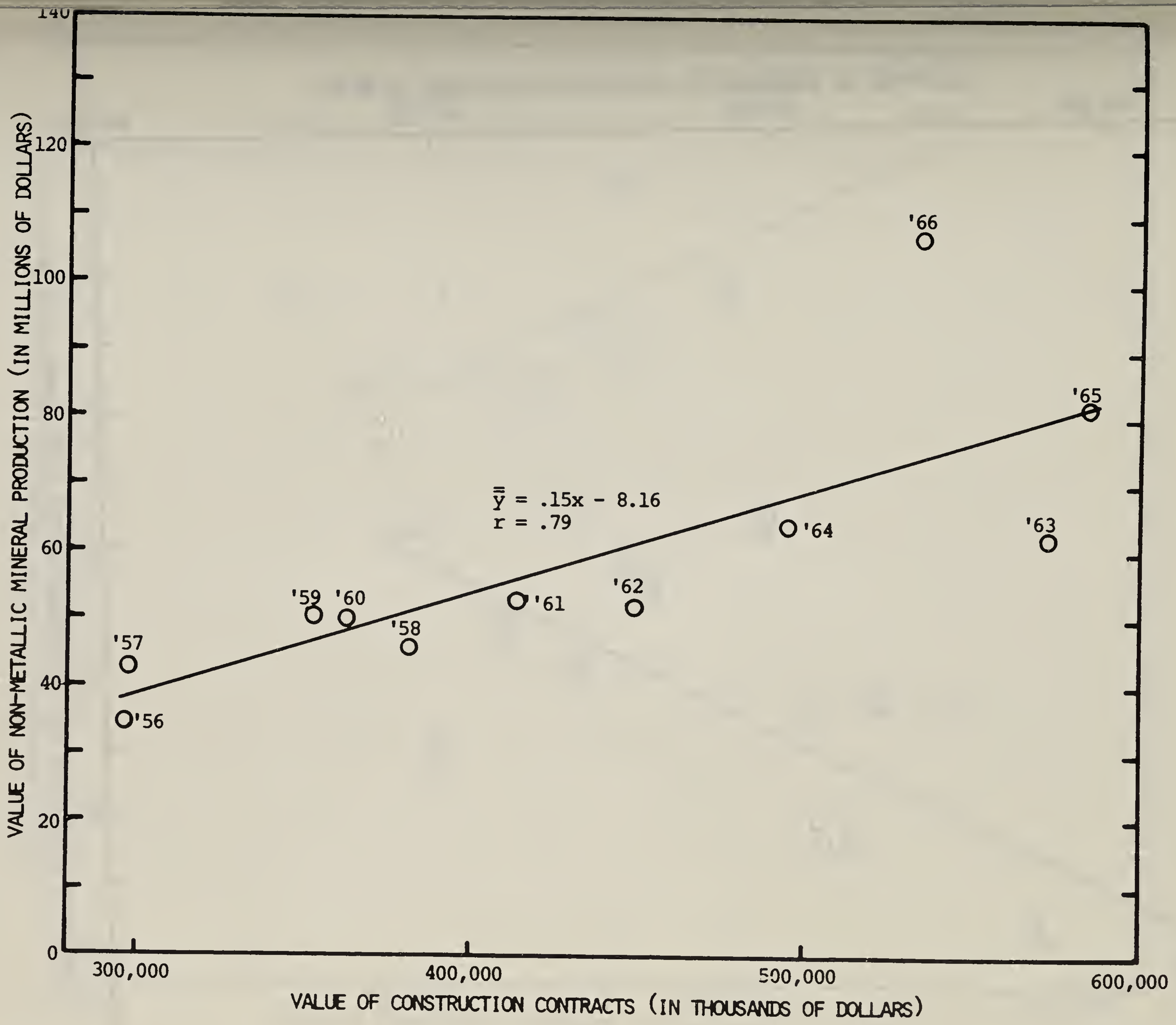
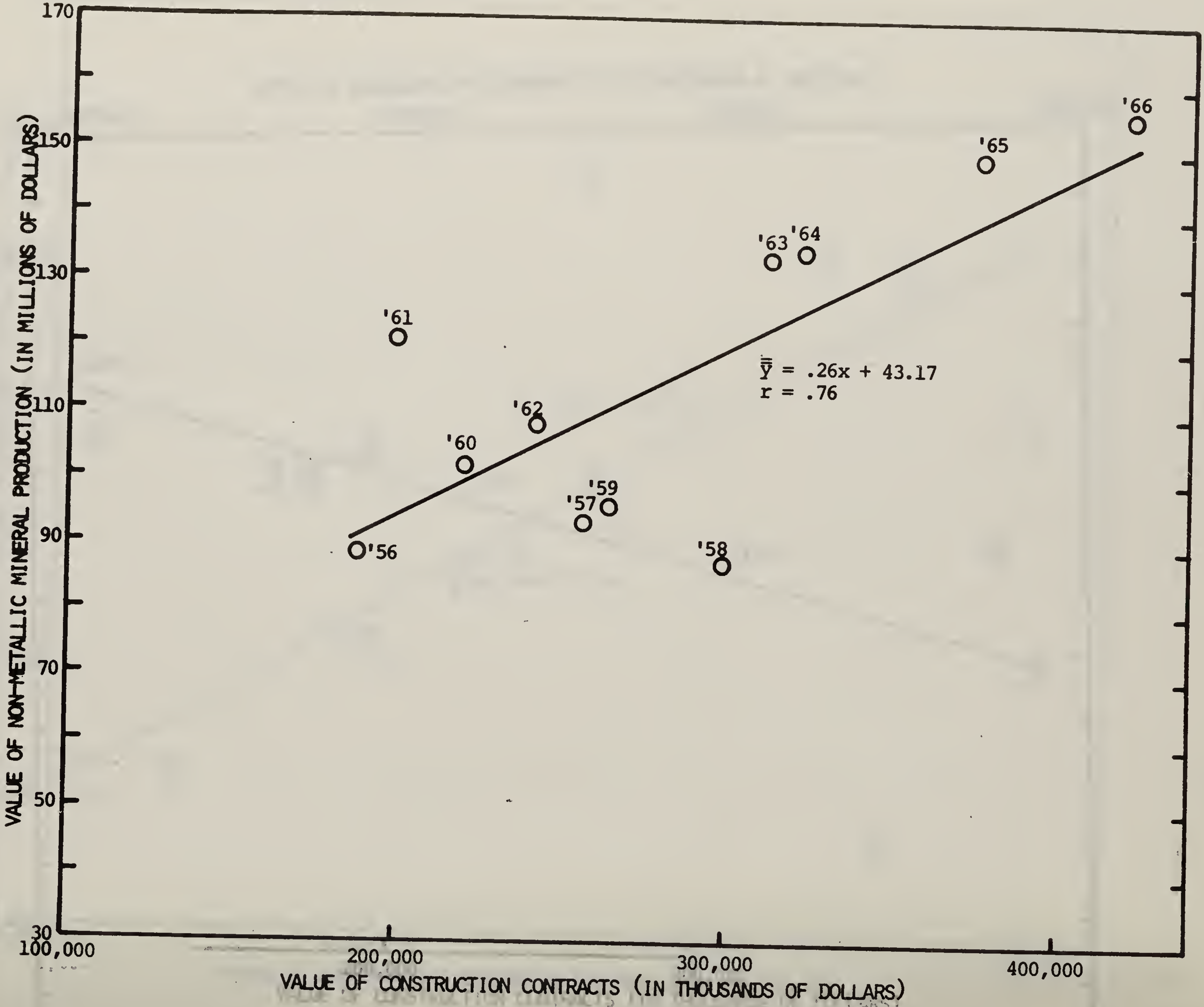


Fig. 64 - Construction activity and industrial minerals production in Oregon, 1956-1966.


VALUE OF NON-METALLIC MINERAL PRODUCTION (IN MILLIONS OF DOLLARS)
170
150
130
110
90
70
50
30
'66
'65
'63
'64
'61
'62
'60
'59
'57
'56
'58
$\bar{\bar{y}} = .26x + 43.17$
$r = .76$
100,000
200,000
300,000
400,000
VALUE OF CONSTRUCTION CONTRACTS (IN THOUSANDS OF DOLLARS)

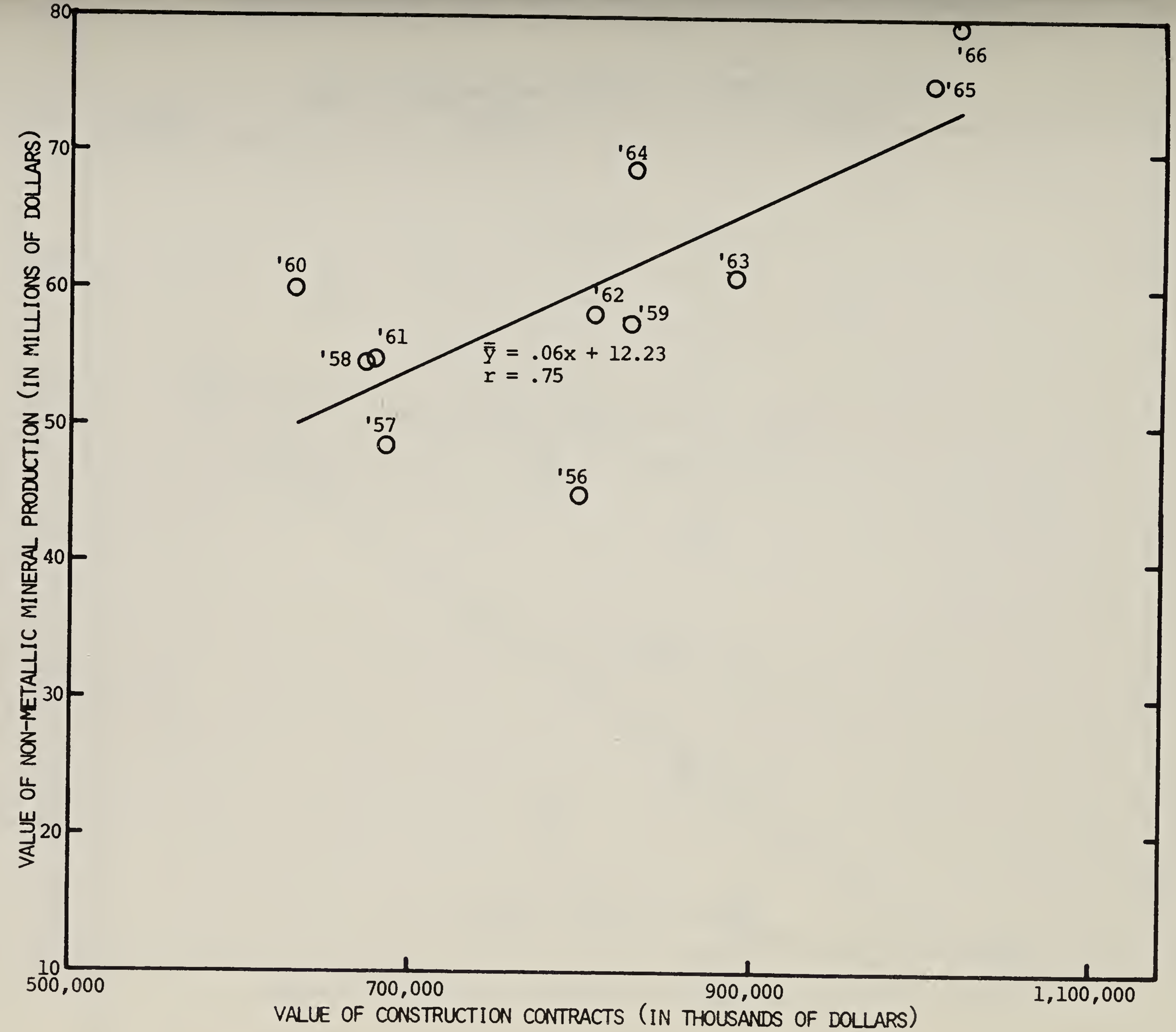


Fig. 66 - Construction activity and industrial minerals production in Washington, 1956-1966.

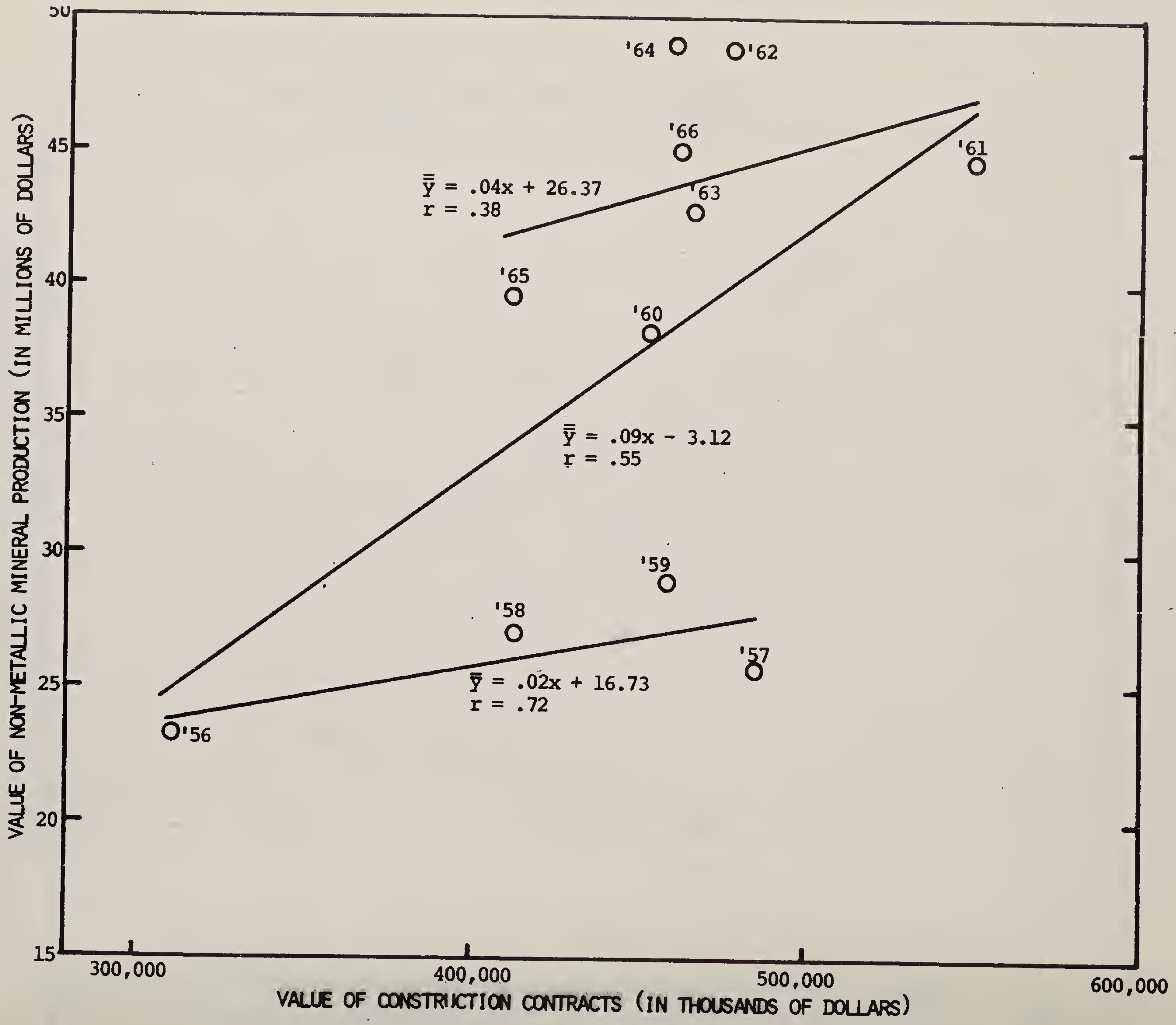


Fig. 67 - Construction activity and industrial minerals production in Arizona, 1956-1966.

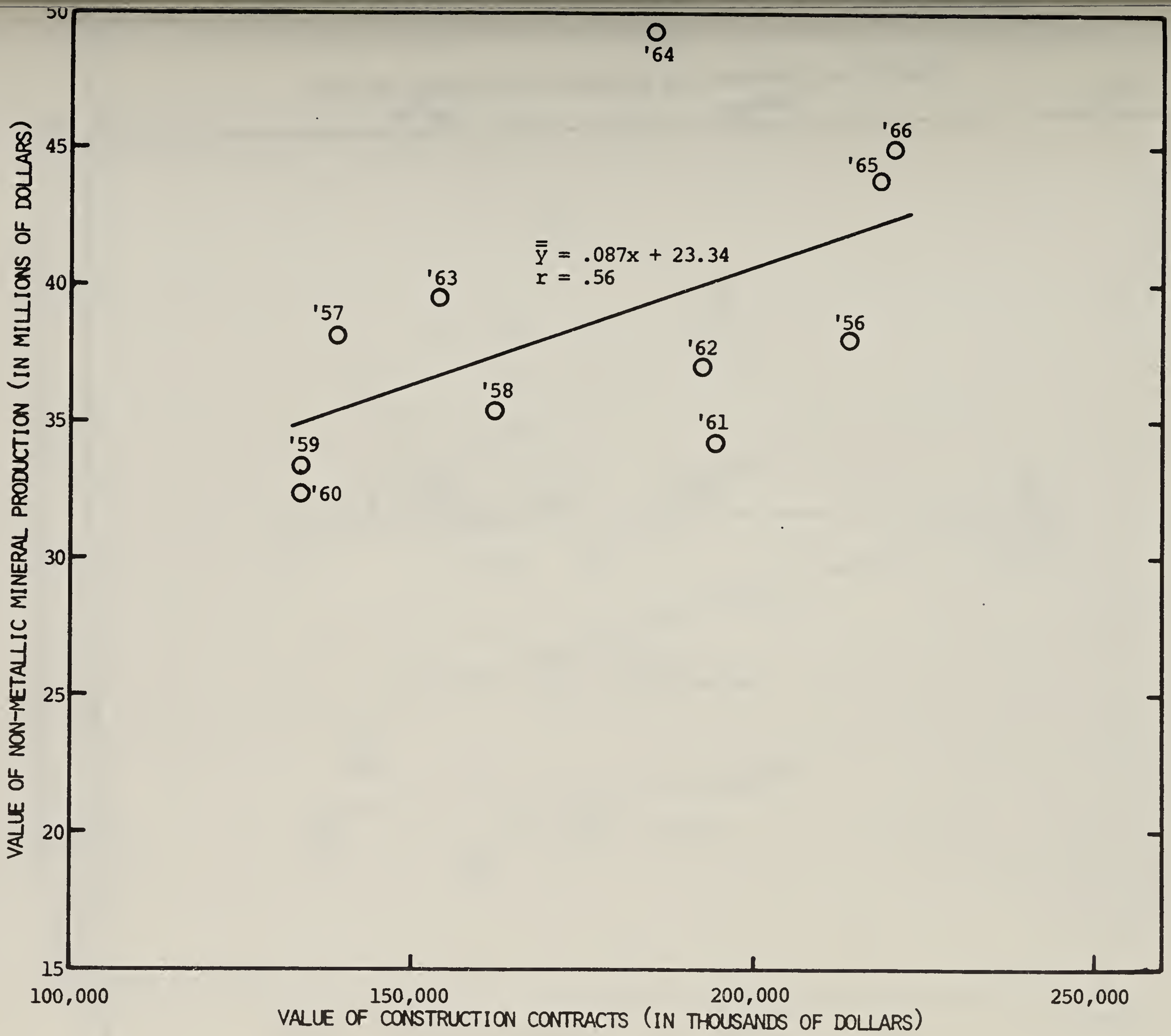
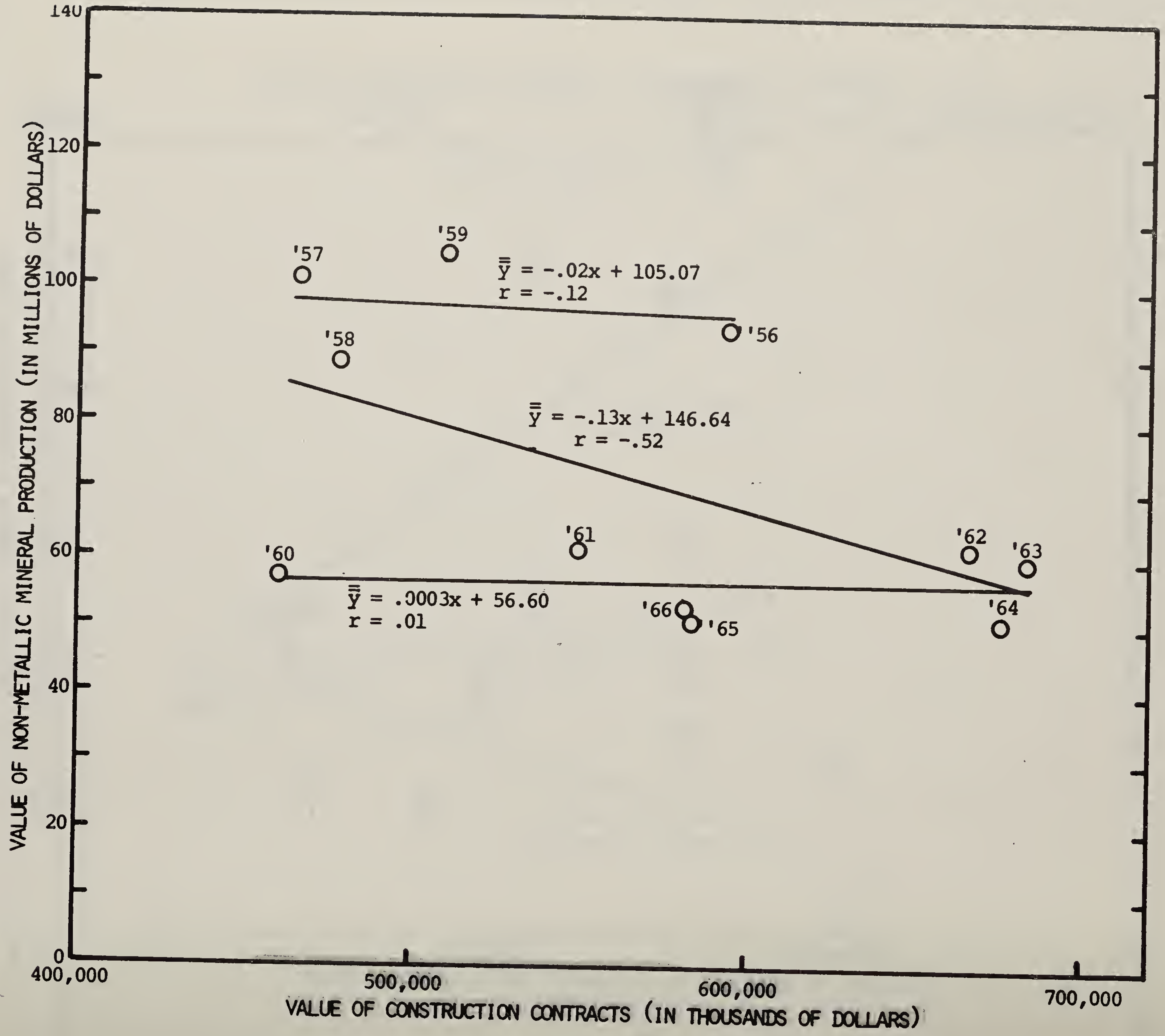


Fig. 68 - Construction activity and industrial minerals production in Montana, 1956-1966.


140
120
100
80
60
40
20
0
VALUE OF NON-METALLIC MINERAL PRODUCTION (IN MILLIONS OF DOLLARS)
400,000
500,000
600,000
700,000
VALUE OF CONSTRUCTION CONTRACTS (IN THOUSANDS OF DOLLARS)
'57
'59
'58
'56
'60
'61
'62
'63
'64
'66
'65
$\bar{\bar{y}} = -.02x + 105.07$
$r = -.12$
$\bar{\bar{y}} = -.13x + 146.64$
$r = -.52$
$\bar{\bar{y}} = .0003x + 56.60$
$r = .01$

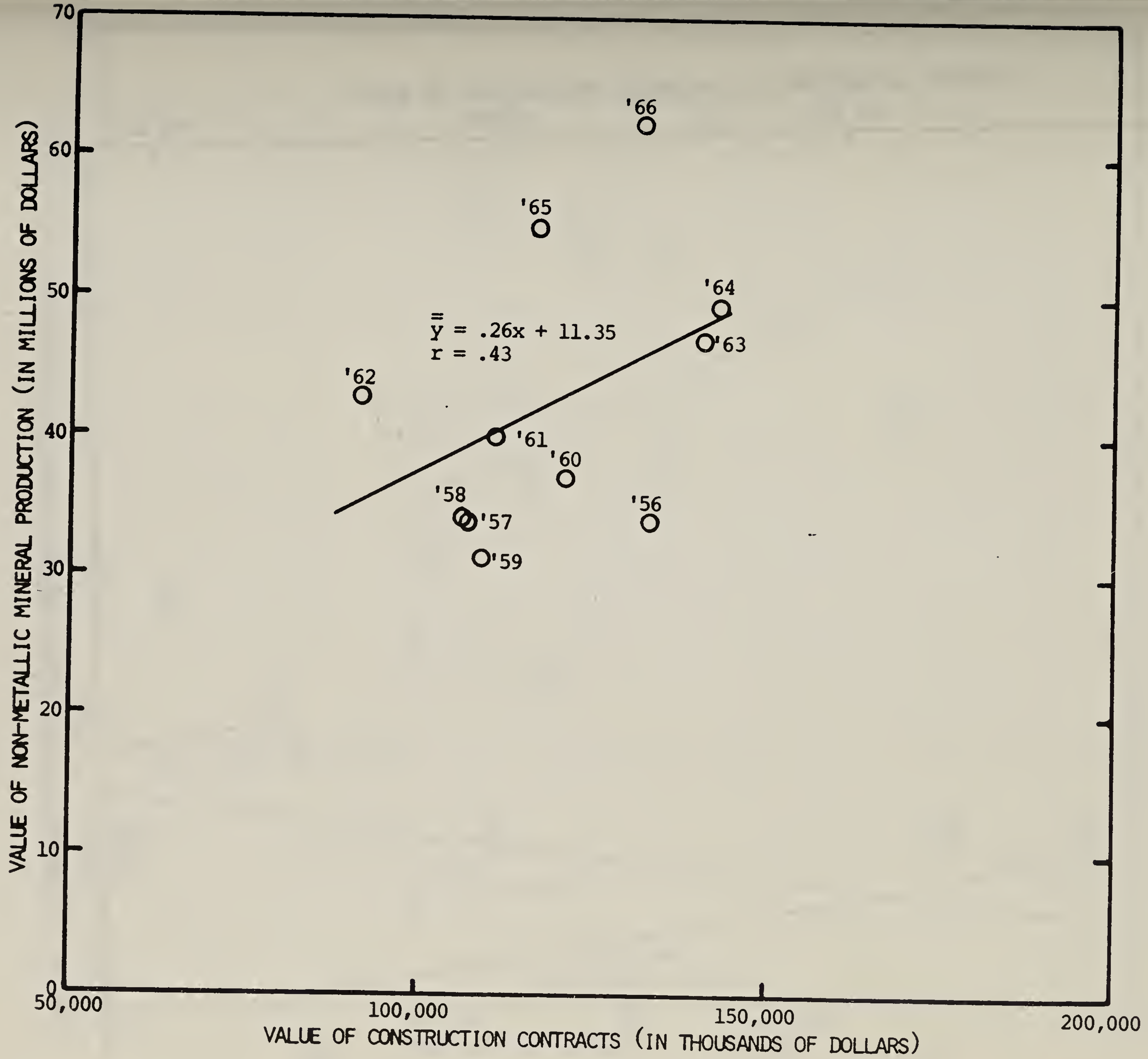
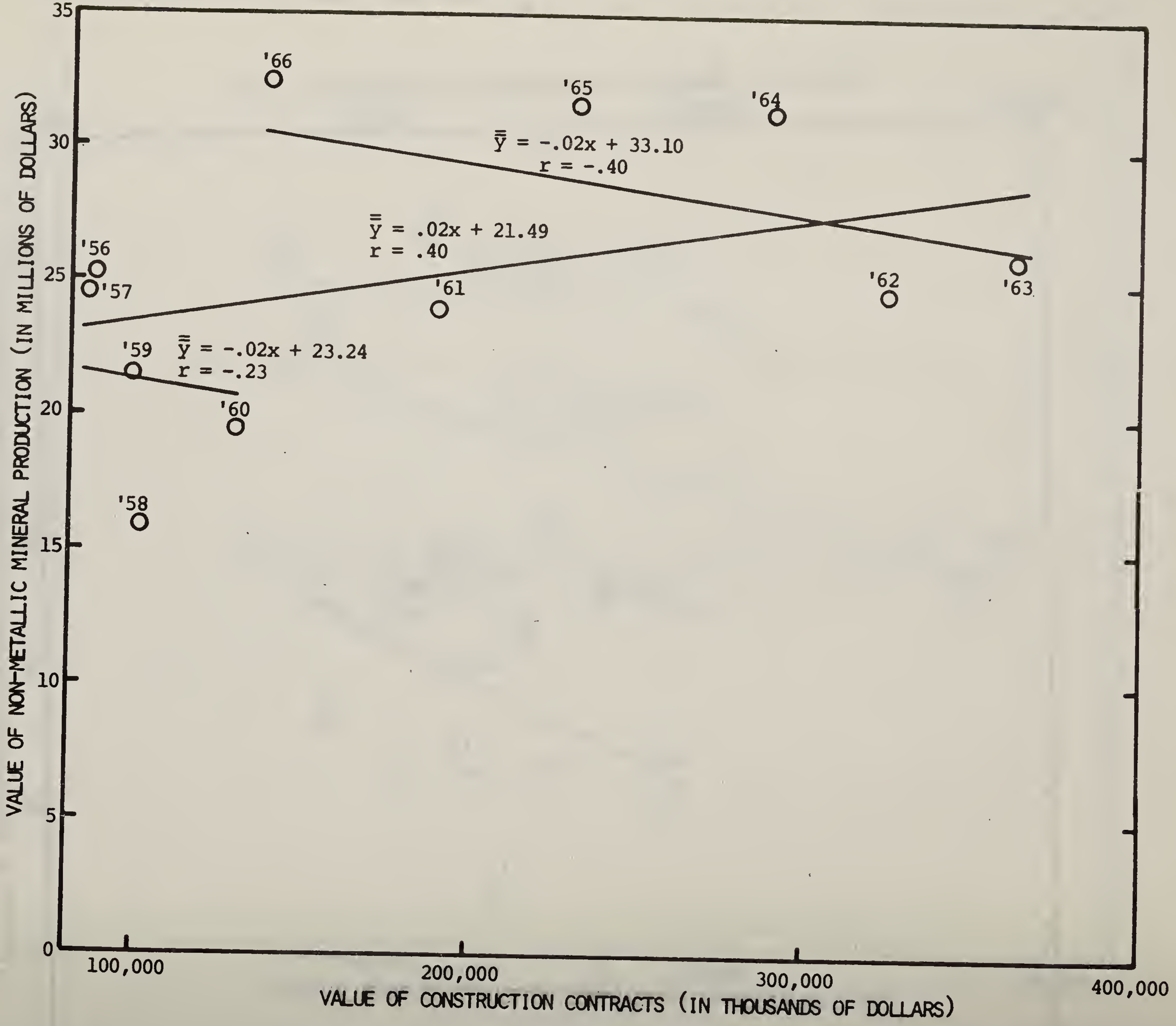


Fig. 70 - Construction activity and industrial minerals production in Wyoming, 1956-1966.


35
30
25
20
15
10
5
0
VALUE OF NON-METALLIC MINERAL PRODUCTION (IN MILLIONS OF DOLLARS)
100,000
200,000
300,000
400,000
VALUE OF CONSTRUCTION CONTRACTS (IN THOUSANDS OF DOLLARS)
'56
'57
'58
'59
'60
'61
'62
'63
'64
'65
'66
$\overline{\overline{\overline{y}}} = -.02x + 33.10$
r = -.40
$\overline{\overline{y}} = .02x + 21.49$
r = .40
$\overline{\overline{\overline{y}}} = -.02x + 23.24$
r = -.23

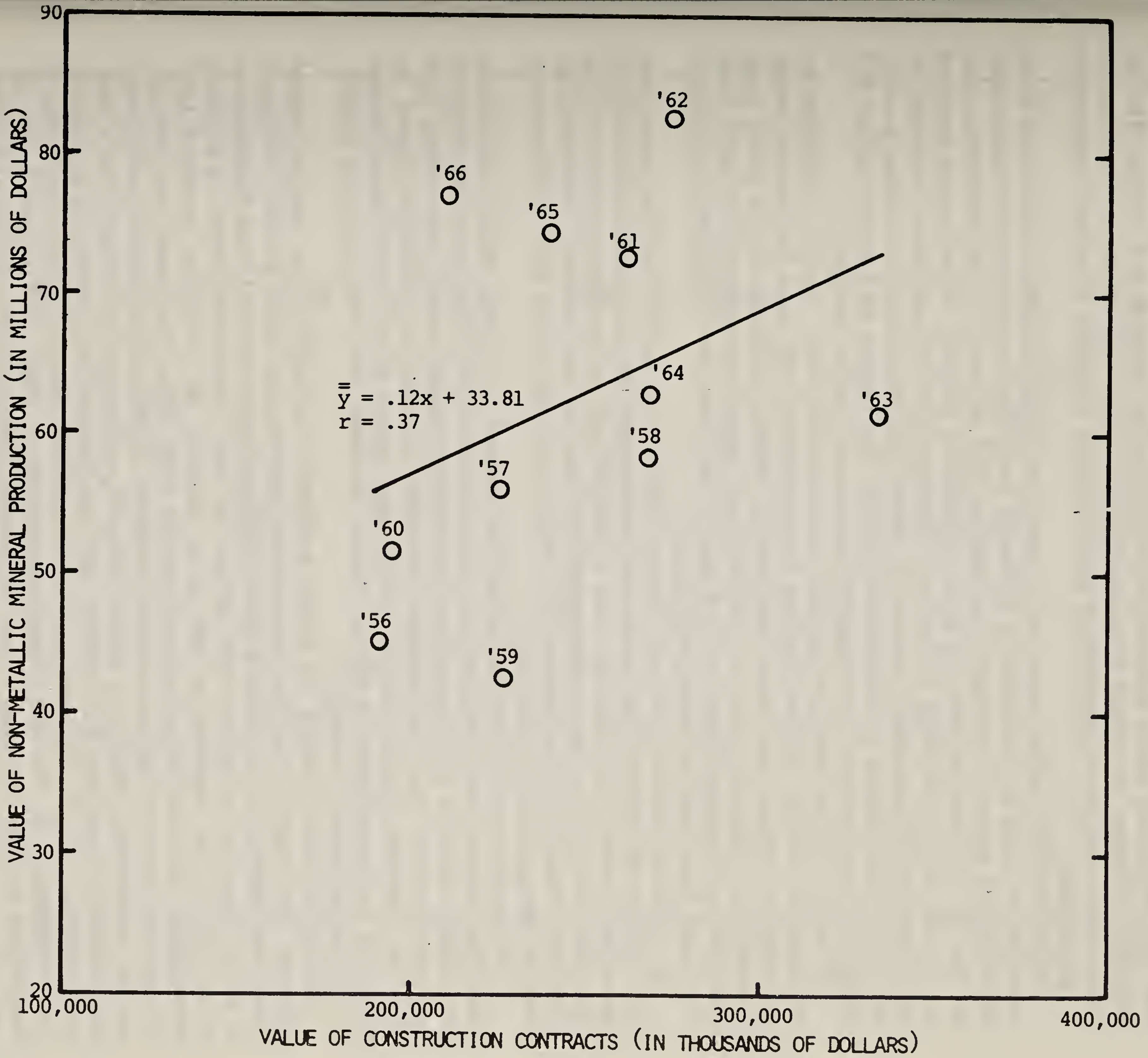


Fig. 72 - Construction activity and industrial minerals production in Utah, 1956-1966.

C. MINERALS AND THE PUBLIC SECTOR

1. Minerals and the Federal Economy

The nonfuel mineral industries of the United States have been a substantial and growing source of revenue for the federal government, through both the payment of federal income and other taxes and direct payment for mineral leases, permits, and licenses. The tax payments, of course, are related to production from both public and private lands, but the lease, permit, and license payments are directly related to the use of mineral resources on the public lands.

In 1948, federal income taxes paid by nonfuel mining corporations in the United States amounted to about $130 million. In that same year, total federal receipts from nonfuel mineral leases, permits, and licenses was less than $12 million. By 1958, the federal taxes had risen to $190 million while the direct payment for federally owned mineral resources had climbed to approximately $55 million. Five years later, federal income taxes paid by nonfuel mining firms were slightly under $200 million and federal receipts for leases, permits, and licenses had climbed to $60 million. In 1966, such receipts hit a peak of almost $85 million, but comparable data for mining income taxes are not yet available.

Virtually all of the federal receipts for nonfuel mineral leases, permits, and licenses are for industrial minerals, because these are the minerals that fall under the minerals leasing and materials disposal laws. Since most metallic minerals utilization on the public lands involves only nominal payments for patenting, most metallic ore mining on the public lands (except on some acquired lands) does not result in significant direct payments to the federal government specifically for mineral resource use.

The corporate income taxes paid by metal mining firms, however, are far greater than those paid by industrial minerals producers. This is despite the fact that the latest available figures show almost three times as many nonmetallic mineral producers as metal mining firms, but with gross receipts approximately the same for each category. Nevertheless, in 1963 metal mining firms paid almost $124 million in federal income taxes while industrial minerals firms paid only $73 million.[19]

If the complete nonfuel minerals industry is examined, i.e., if those manufacturing firms classified as primary metal industries and those involved in producing stone, clay, and glass products are added to metal mining and nonmetallic minerals (except fuels) mining, then the federal receipts from the utilization of nonfuel minerals are considerably higher. In 1963, the complete nonfuel minerals industry paid almost $1.6 billion in federal income taxes. The total contribution to federal revenues, including both taxes and leases, permits, and licenses, exceeded $1.6 billion.

The expenditures made by the federal government on behalf of the nonfuel mineral industries have been far less than the amounts received from them. In 1947, combined federal appropriations for the United States Geological Survey and the United States Bureau of Mines amounted to less than $26 million. Of this, a portion was spent on activities related to the fuel minerals as well as to nonfuels. By 1967, the combined total appropriation for these two agencies had reached $105 million. That same year, however, other federal agencies concerned with the utilization of other resources on the public lands received considerably more. The United States Forest Service, for example, had a total appropriation of more than $225 million, while the National Park Service used $36 million and the Bureau of Sports Fisheries and Wildlife used more than $37 million. The Bureau of Land Management in 1967 had a total appropriation of almost $49 million.[20] The net contribution to federal revenues of nonfuel minerals firms alone thus exceeds $1.5 billion per year.

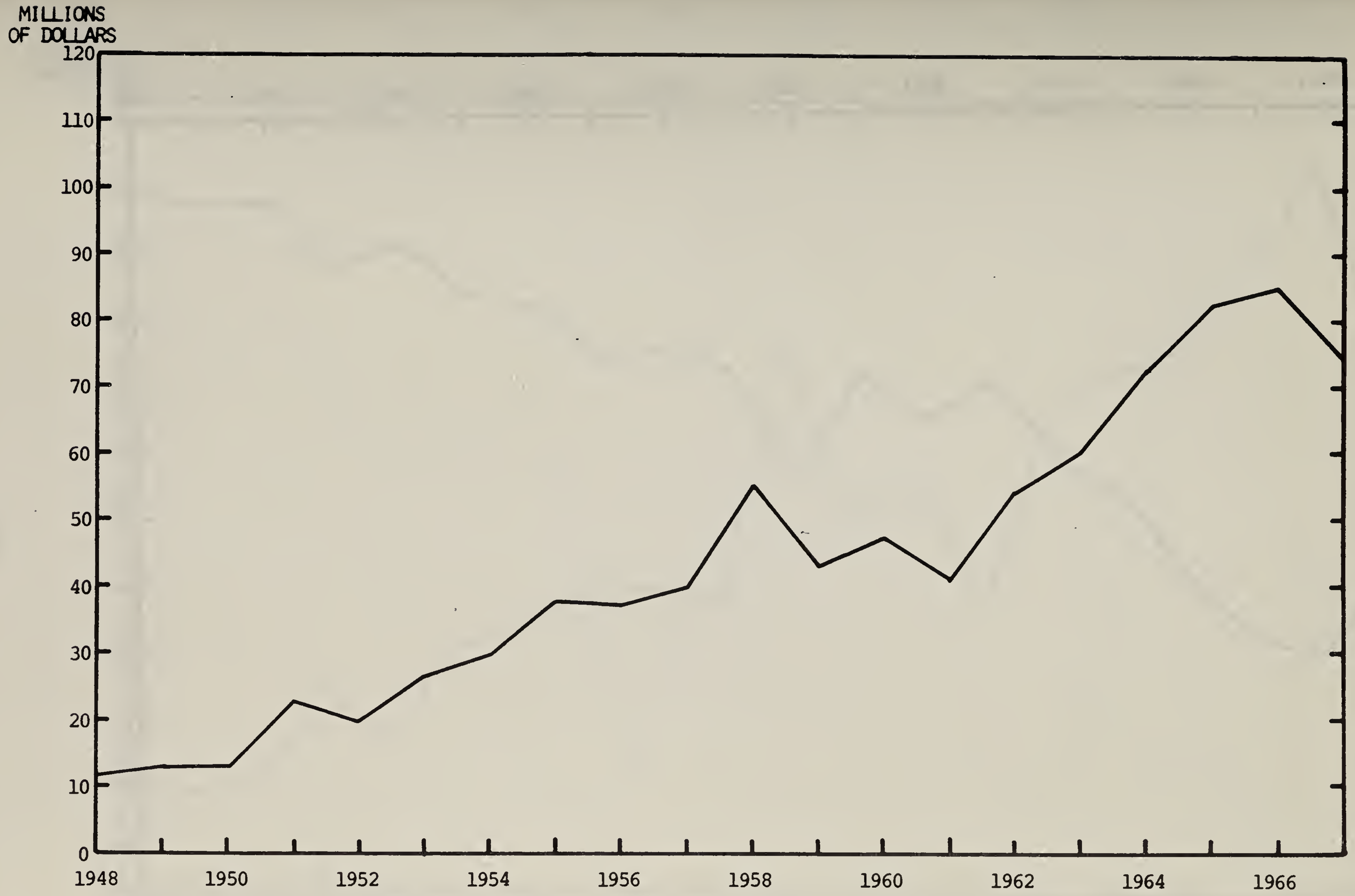


Fig. 73 - Federal receipts from nonfuel mineral leases, permits, and licenses in the United States.

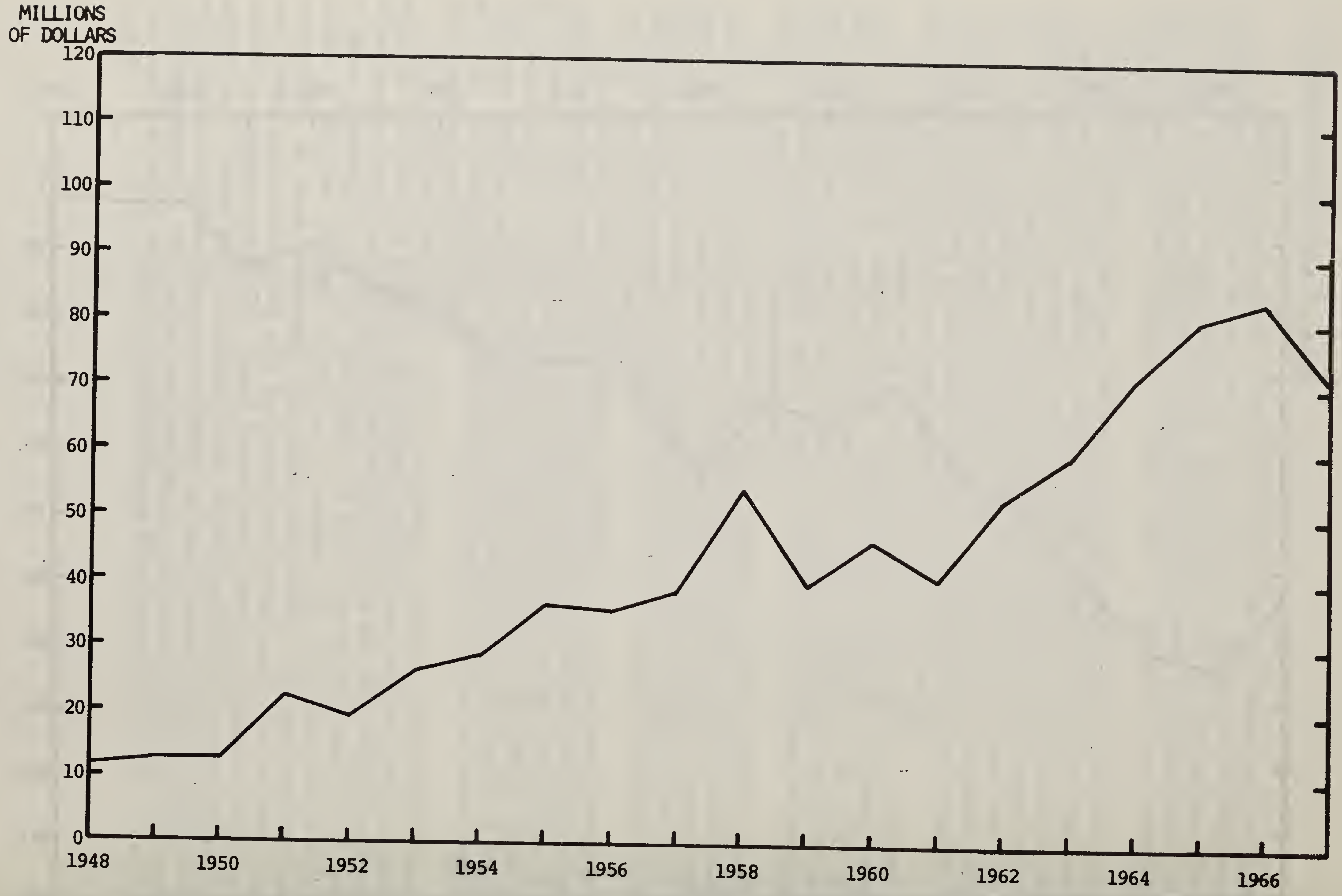


Fig. 74 - Federal receipts from nonfuel mineral

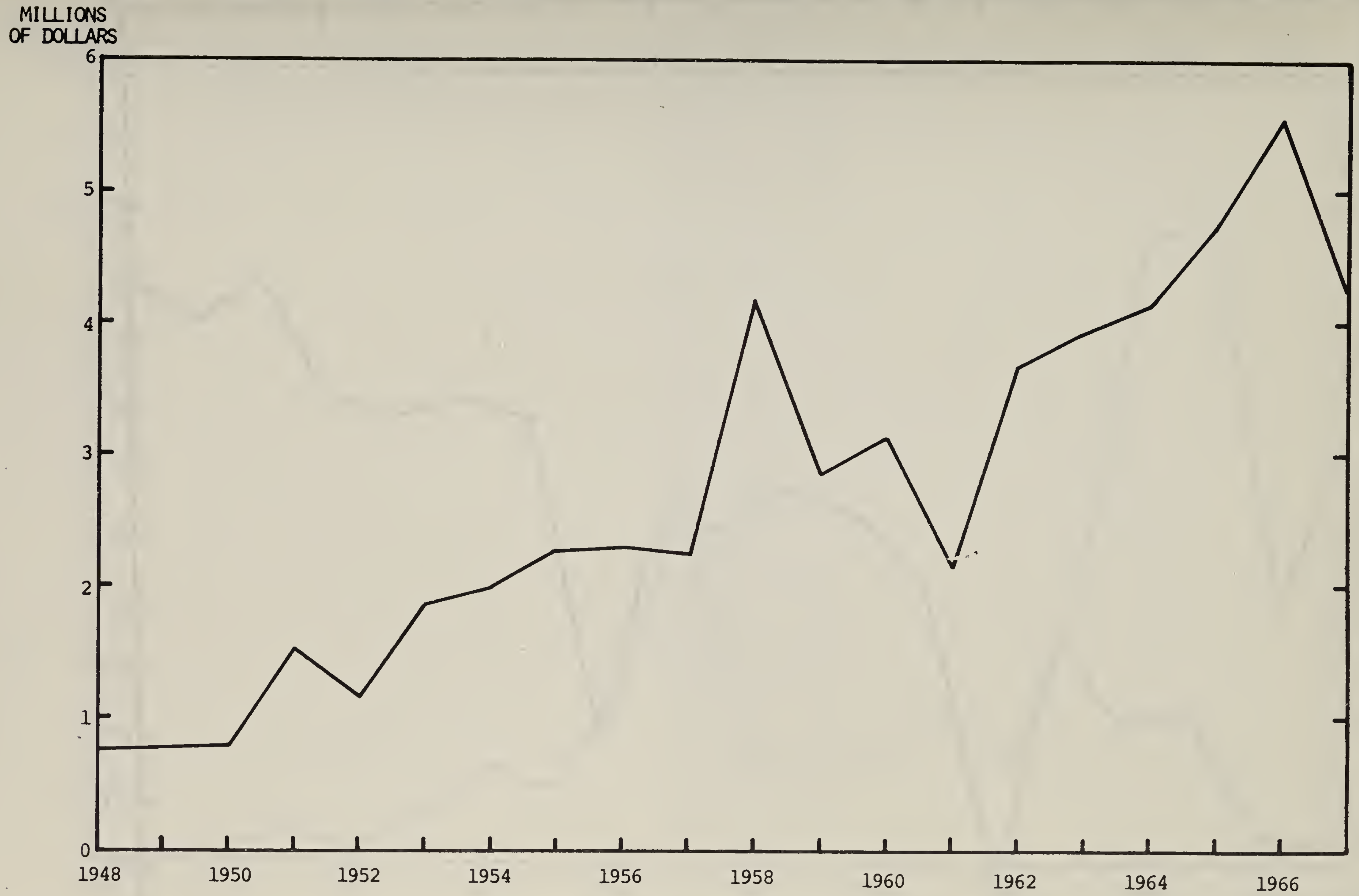
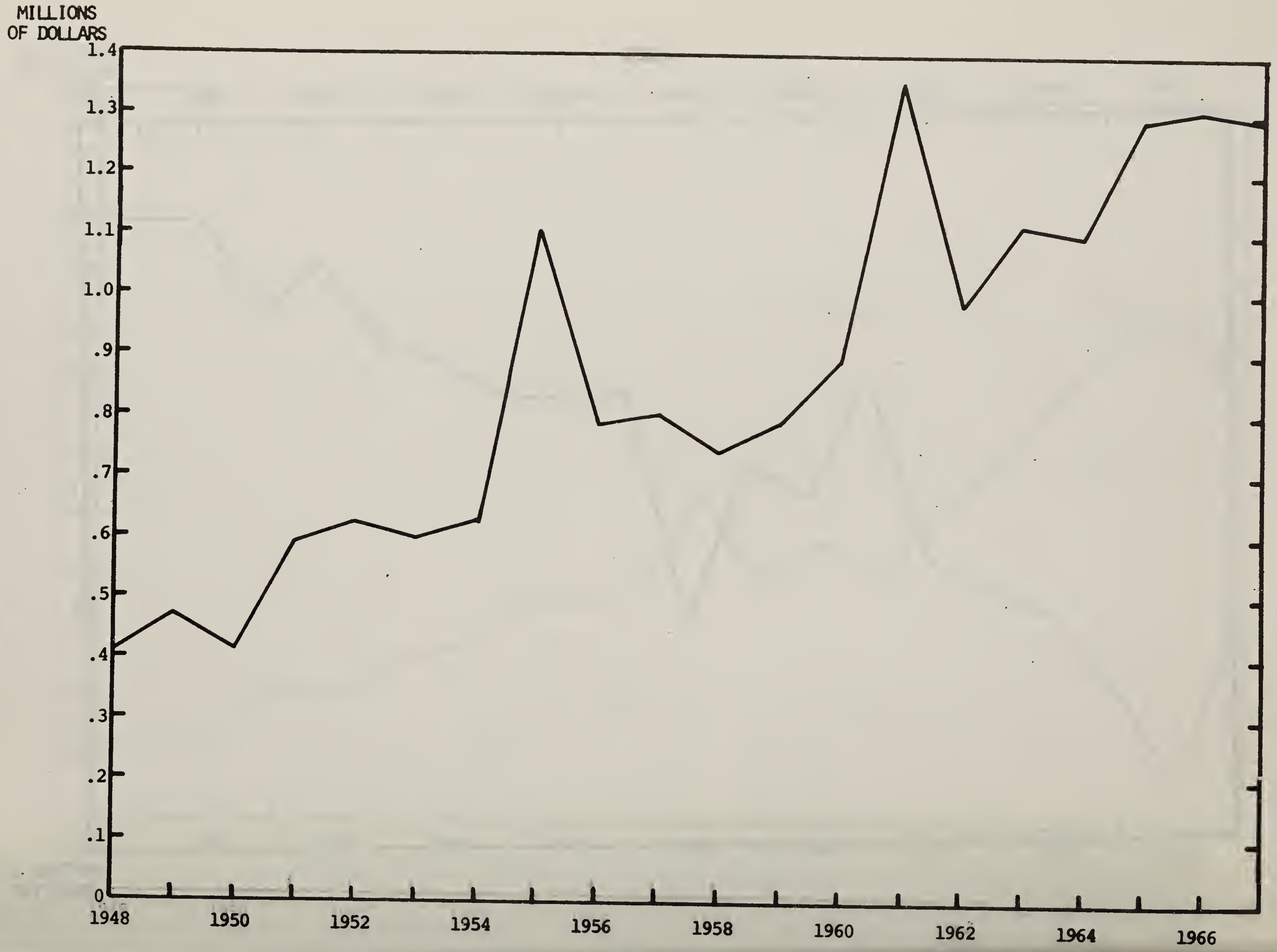


Fig. 75 - Federal receipts from nonfuel mineral leases, permits, and licenses in New Mexico.


MILLIONS
OF DOLLARS
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966

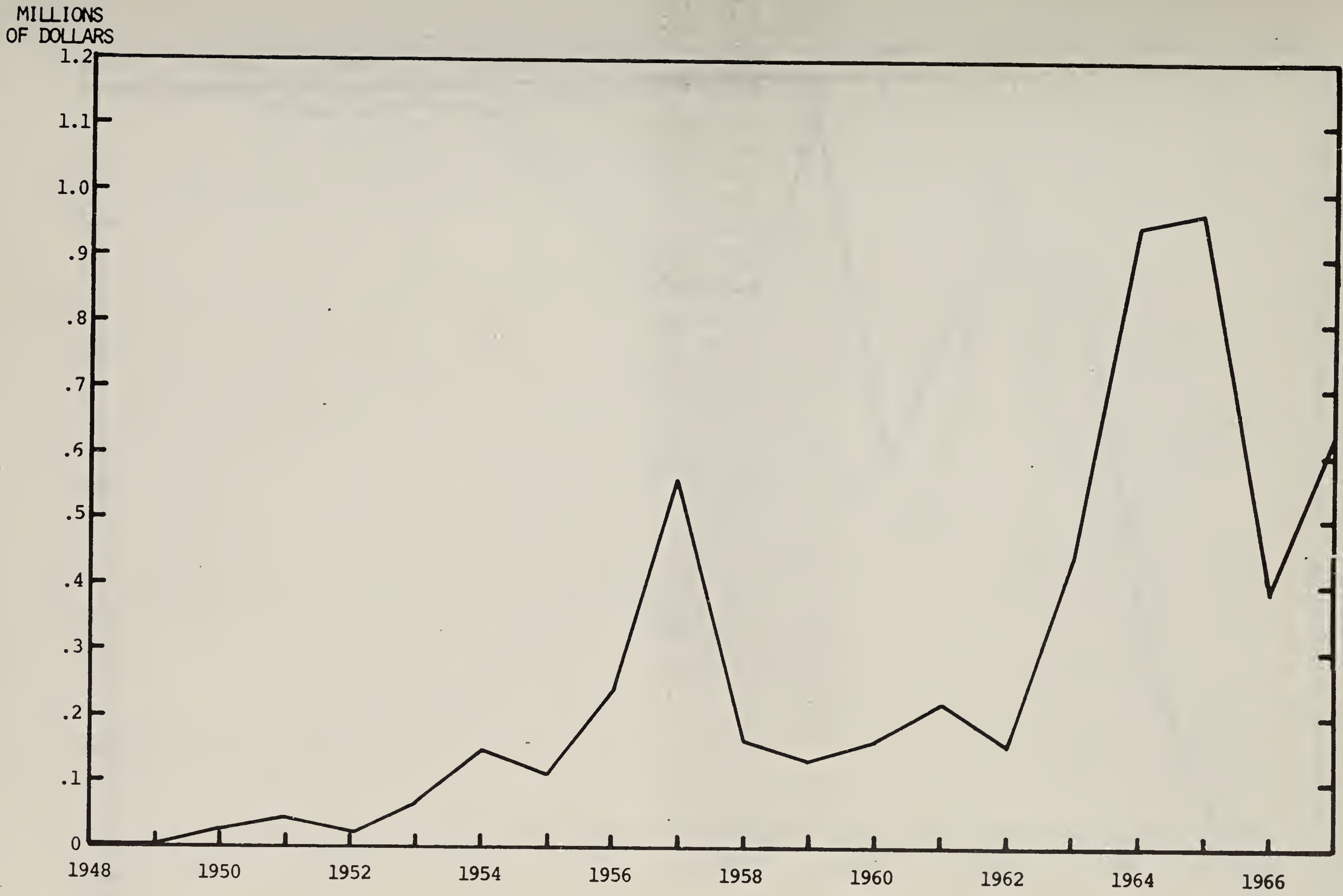


Fig. 77 - Federal receipts from nonfuel mineral leases permits, and licenses in Idaho.

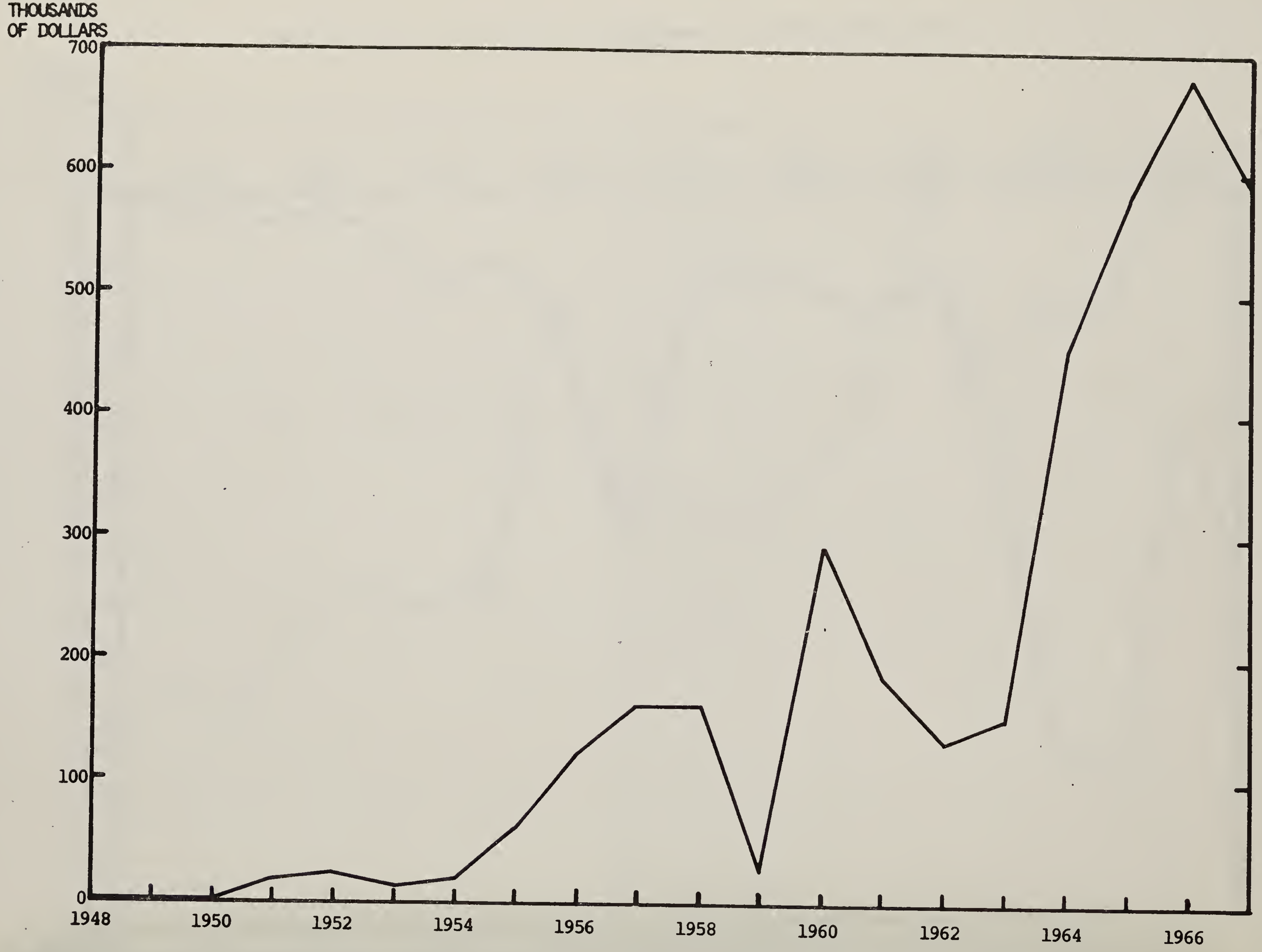


Fig. 78. Federal receipts

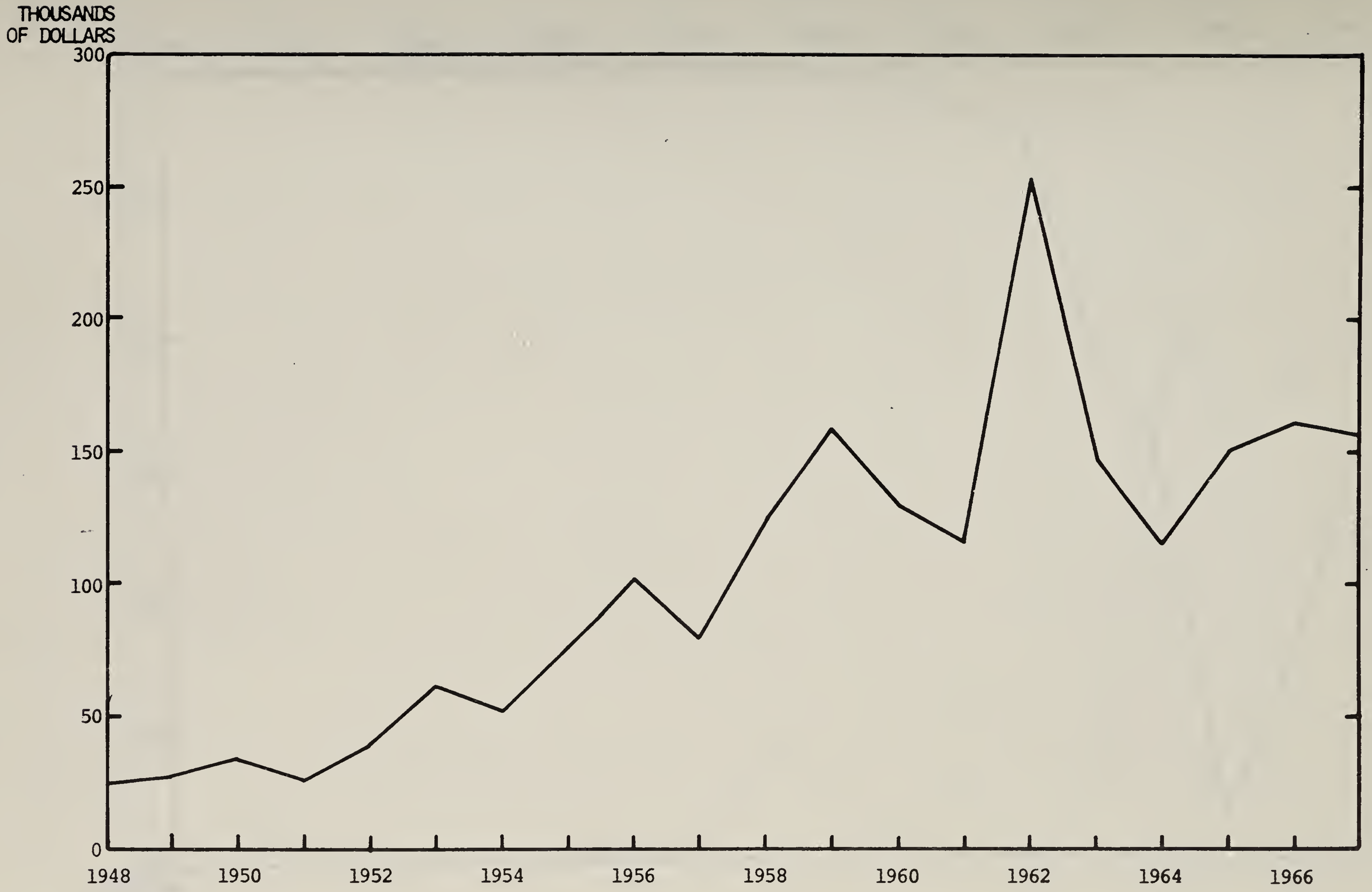
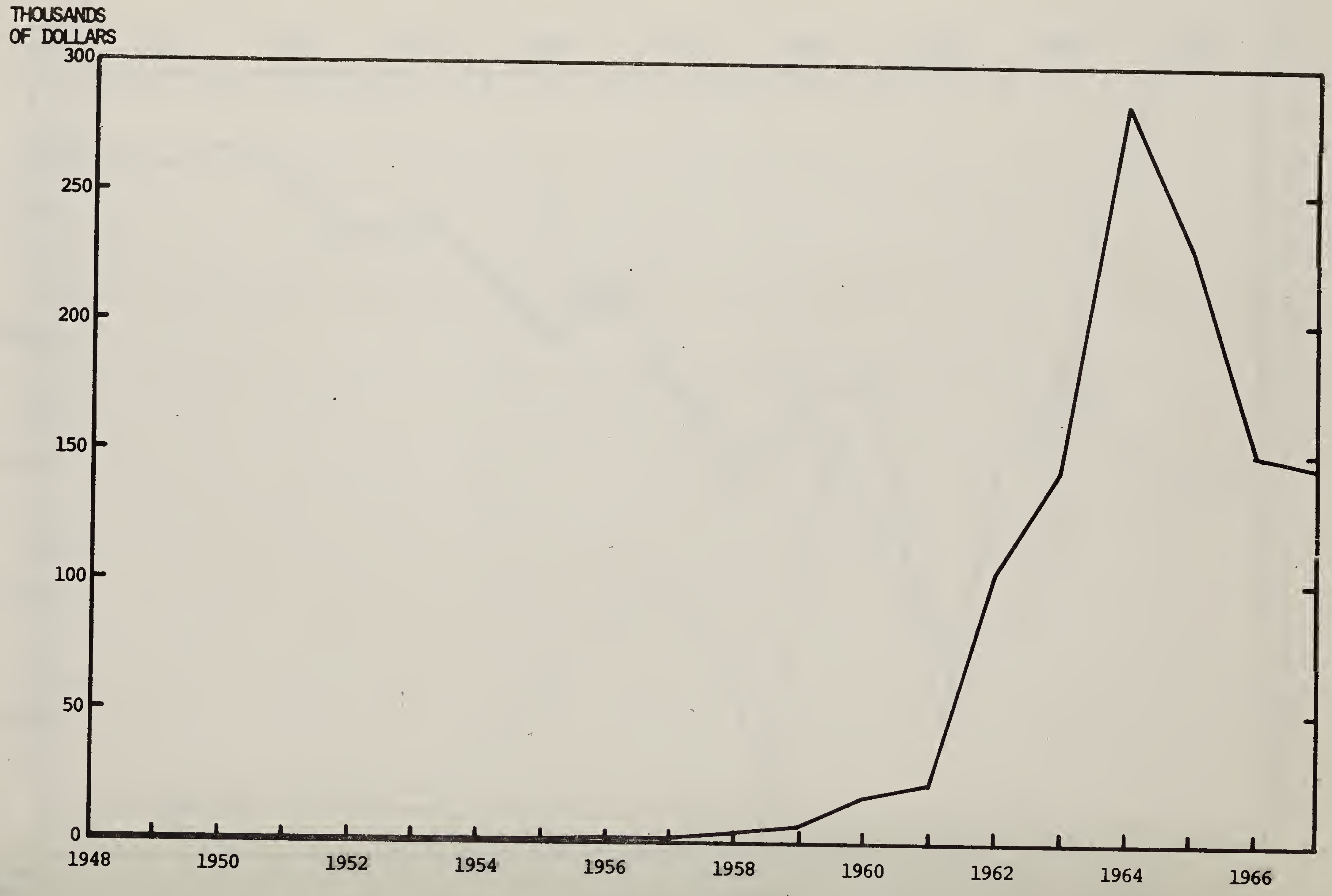


Fig. 79 Federal receipts from nonfuel mineral leases, permits, and licenses in Montana.


THOUSANDS
OF DOLLARS
300
250
200
150
100
50
0
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966

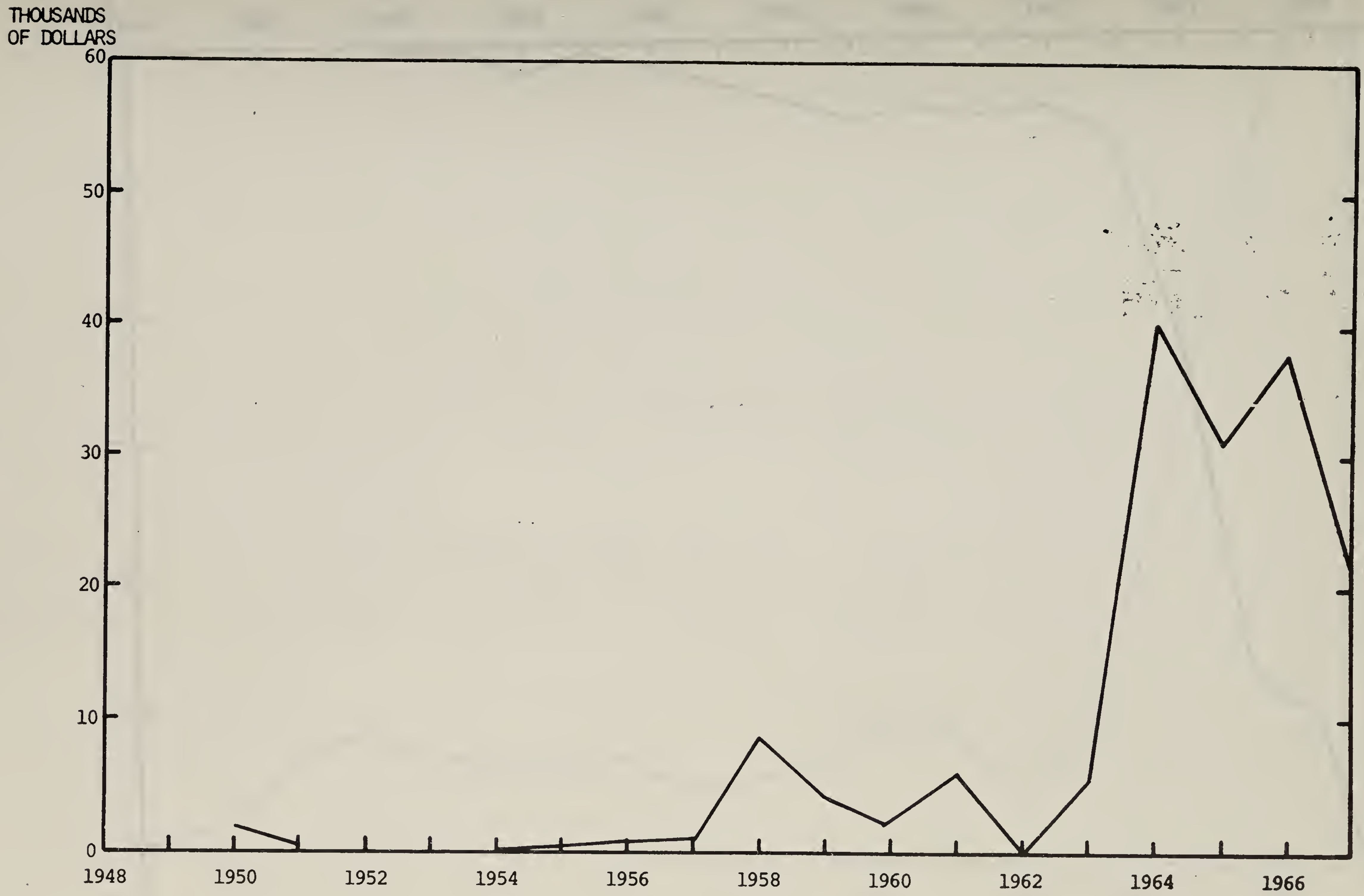
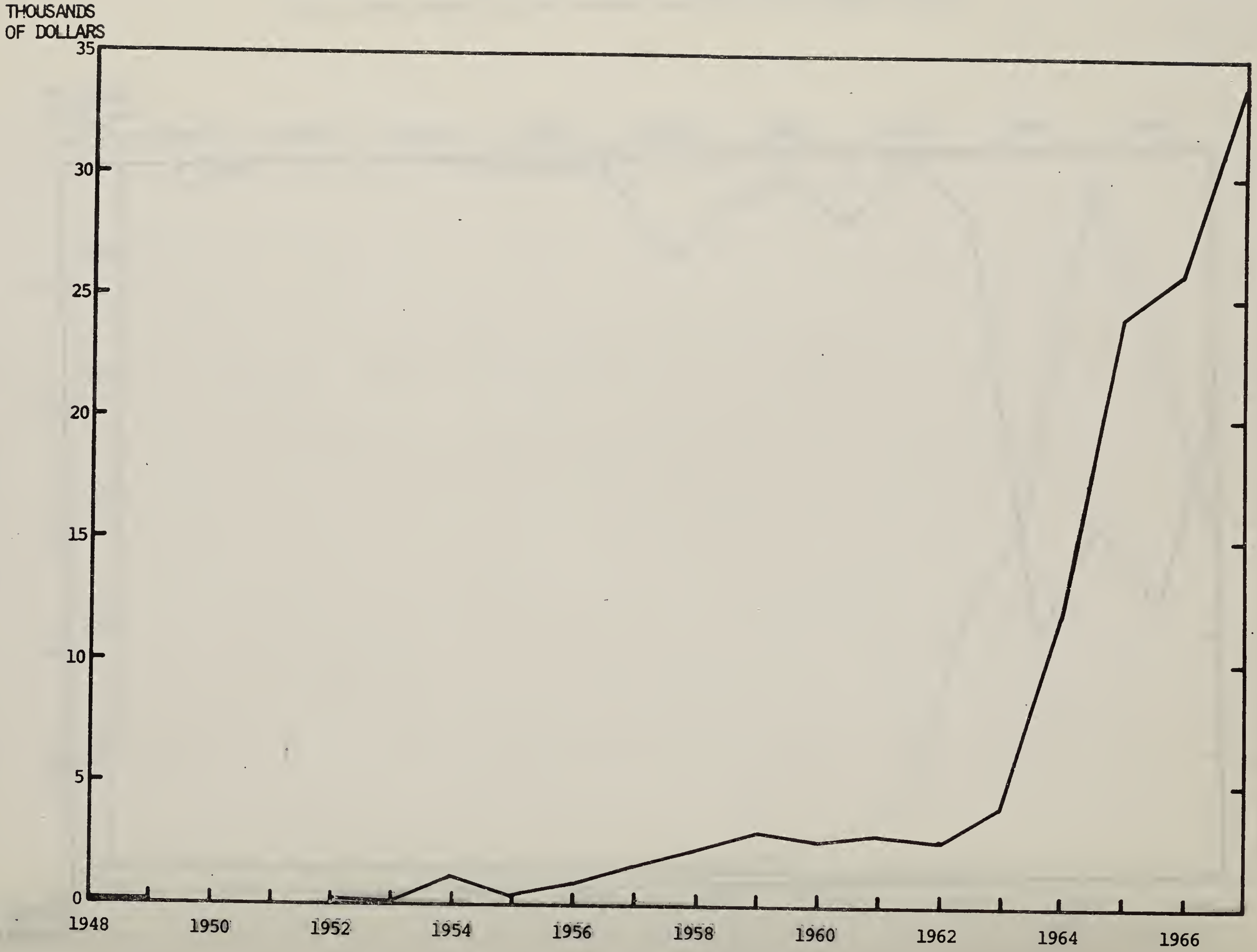


Fig. 81 - Federal receipts from nonfuel mineral leases, permits, and licenses in Arizona.


THOUSANDS
OF DOLLARS
35
30
25
20
15
10
5
0
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966

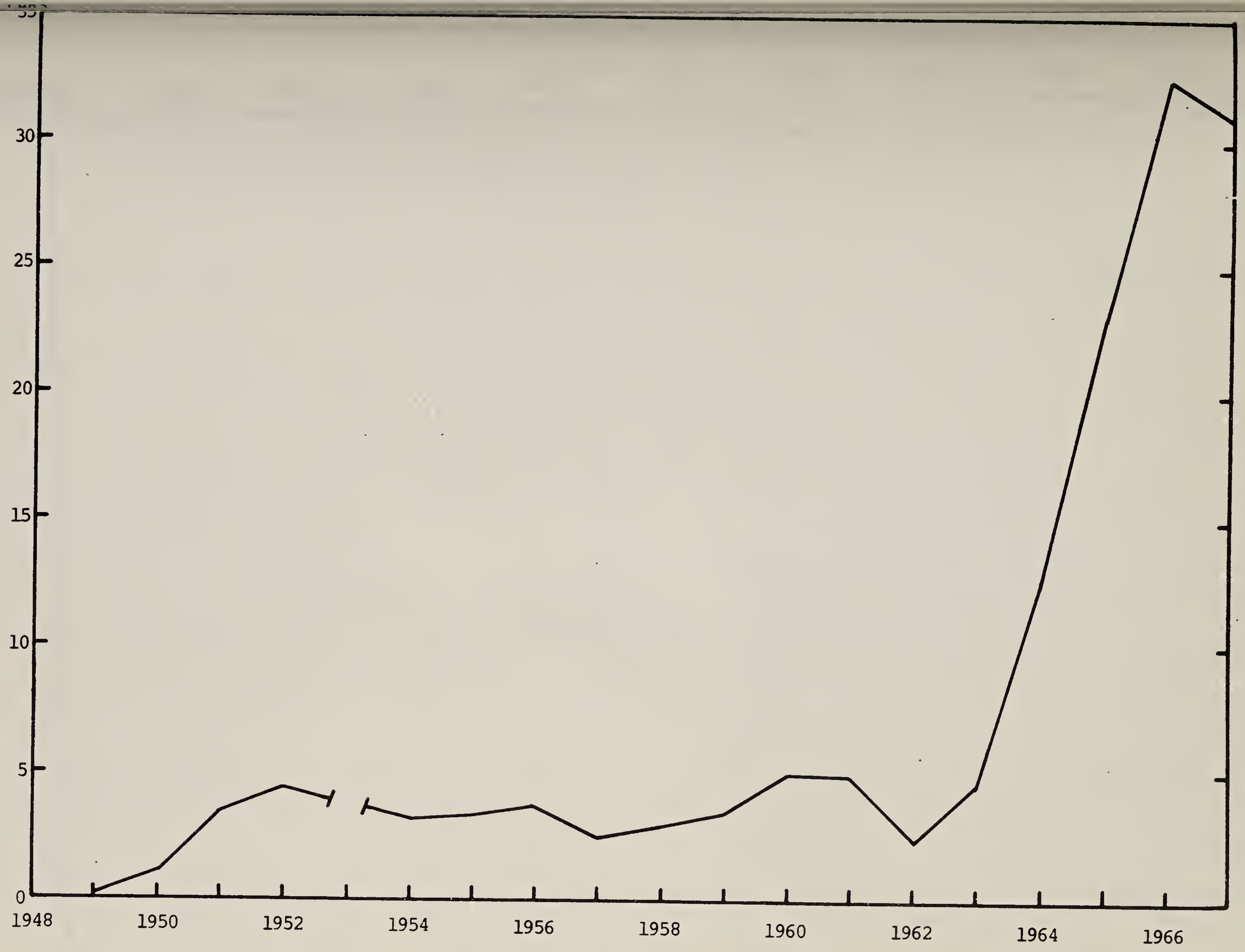
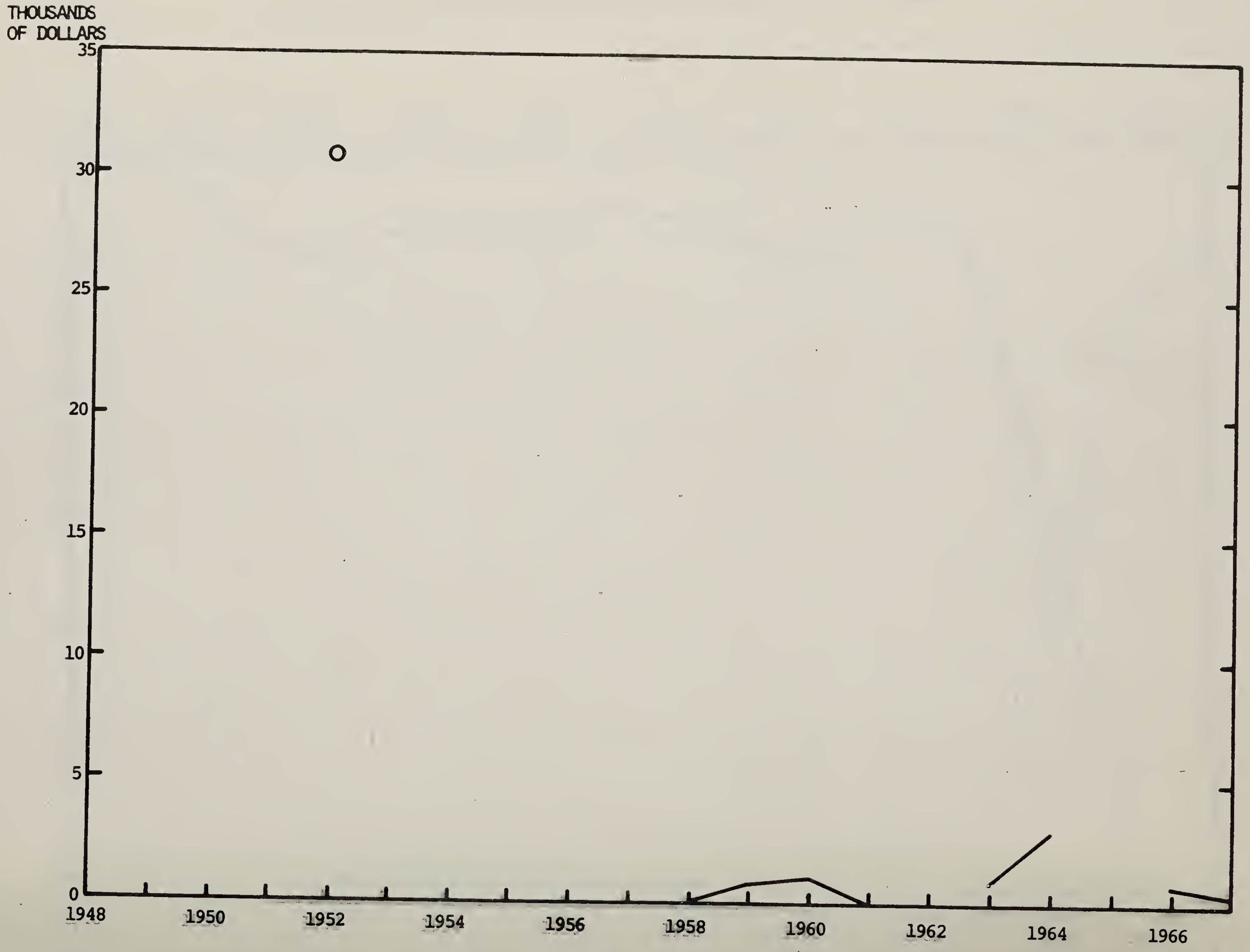


Fig. 83 - Federal receipts from nonfuel mineral leases, permits, and licenses in Nevada.


THOUSANDS
OF DOLLARS
35
30
25
20
15
10
5
0
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966

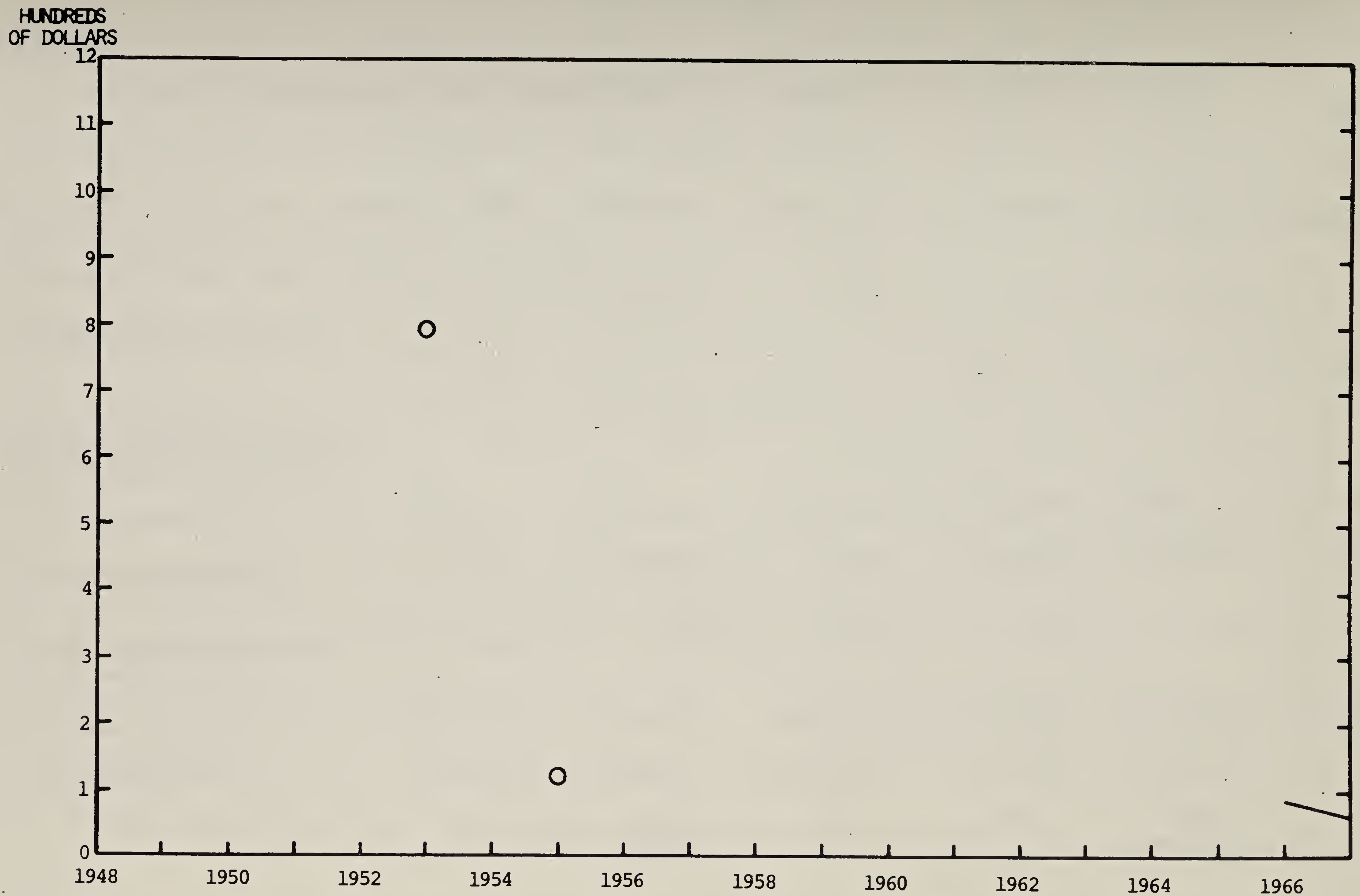


Fig. 85 - Federal receipts from nonfuel mineral leases, permits, and licenses in Washington.

Table 4

TOTAL MINING REVENUE AND EXPENDITURES AND TOTAL STATE REVENUE AND EXPENDITURES: 1965-67

	Arizona			New Mexico		
	1965	1966	1967	1965	1966	1967
Total Mining Revenue[a]	37,450,289	38,665,757	46,046,334	21,055,592	22,529,076	24,094,905
Total State Revenues[a]	304,584,499[b]	357,076,475[b]	394,805,521[b]	287,900,000[c]	315,800,000[c]	342,200,000[c]
Total Mining Revenue as a Percent of Total State Revenues	12.29	10.82	11.66	7.31	7.13	7.04
Total Mining Expenditures[a]	208,483	206,493	205,588	2,400,606	2,704,794	2,917,324
Total State Expenditures[a]	294,246,377[b]	353,537,483[b]	404,566,708[b]	245,700,000[e]	278,844,742[e]	299,100,000[f]
Total Mining Expenditures as a Percent of Total State Expenditures	.05	.05	.05	.97	.97	.97

[a] Figures in thousands in dollars.

[b] *Arizona State Auditor Report* FYE 1965-1968, pp. 6 and 7.

[c] *New Mexico Annual Financial Report* FYE 1965-1968, pp. 20 and 37.

[d] *Colorado Department of Revenue Annual Report* FYE June 30, 1968, p. 20.

[e] *Facts and Figures on Government Finance,* Tax Foundation, Inc., 1967 and 1969 edition, pp. 160 and 170.

[f] Estimated.

Table 4 (Continued)

	Montana			Colorado		
	1965	1966	1967	1965	1966	1967
Total Mining Revenues[a]	7,803,819	8,927,004	9,328,087	2,913,765	3,180,859	3,180,212
Total State Revenues[a]	145,900,000[e]	165,314,889	170,900,000[e]	275,029,851[d]	341,131,698[d]	361,608,819[d]
Total Mining Revenue as a Percent of Total State Revenues	5.34	5.40	5.45	1.05	.93	.87
Total Mining Expenditures[a]	NA	NA	NA	NA	NA	NA
Total State Expenditures[a]	NA	NA	NA	NA	NA	NA
Total Mining Expenditures as a Percent of Total State Expenditures	NA	NA	NA	NA	NA	NA

[a] Figures in thousands of dollars.

[b] *Arizona State Auditor Report* FYE 1965-1968, pp. 6 and 7.

[c] *New Mexico Annual Financial Report* FYE 1965-1968, pp. 20 and 37.

[d] *Colorado Department of Revenue Annual Report* FYE June 30, 1968, p. 20.

[e] *Facts and Figures on Government Finance,* Tax Foundation, Inc., 1967 and 1969 edition, pp. 160 and 170.

[f] Estimated.

2. Minerals and State and Local Public Finance

Because of an extreme paucity of state and local data related specifically to the nonfuel mineral industries, any study of the role of minerals in the public sector of the regional economy of the Western States must be limited. This study has thus been limited to a select number of states in which adequate data are available. These, of course, tend to be those in which the nonfuel mineral industries are of greater significance. Nevertheless, the analyses are presented herein as representative of those Western States in which mineral resources are of similar importance. The detailed data on the states analyzed (Arizona, Colorado, Montana, and New Mexico) have been further supplemented by primary sample data for the entire region.

State and local governments in Arizona, Colorado, Montana, and New Mexico have each received significant sums from mine taxation in recent years. The state revenues derived from the mineral industries have been in the form of real and personal property taxes, income taxes, production taxes, sales taxes, license taxes, severance taxes, and royalties.

Data are not available to determine the expenditures made by all these states in regulating and assisting their mineral industries. Arizona and New Mexico, however, have made funds specifically available to support mining regulatory agencies and mineral research activities. Other state expenditures include those for a copper tariff board, an oil conservation commission, and a miners' hospital.

A convenient summary of the total effect of mining in these four states is given in Table 4. Arizona's total mining revenues from 1965 to 1967 roughly approximated $40 million, better than 11 percent of that state's total revenues during that period. New Mexico's mines provided that state with better than $22 million each year between 1965 and 1967, a little better than seven percent of that state's total revenue. For Montana, the mines generated nearly 5.5 percent of total state revenue, which made for an average yearly figure in excess of $8 million. Colorado's yearly $3 million or so from the mineral industry represented only one percent of that state's total revenues. In Arizona and New Mexico, state expenditures directly for the mining industry represented only one-half of one percent (in Arizona) and one percent (in New Mexico) of total state outlays. These small outlays left very healthy net fiscal proceeds from mineral resource utilization for these two states.

Based on a representative sample of county tax officials in all of the 11 Western States, a total contribution to local tax revenues by minerals producers was estimated. Estimates for each state are shown in Table 5. For the 1965-1968 period as a whole, the mean contribution per county per year was in excess of $386,000. Variation among counties, however, was extremely high, ranging from zero for many localities to millions of dollars in others. The total contribution to local government revenues throughout the West is estimated at nearly $200 million for 1967. The distribution of these revenues, however, is far from uniform. If both local and state revenues are combined, in scarcely any western state can the contribution of mining to governmental finances be seen as an insignificant consideration.

Table 5

STATE GOVERNMENT REVENUES AND THE MINERAL INDUSTRIES' CONTRIBUTIONS IN THE WESTERN STATES, 1967

State	Mining Revenues	Total Revenues
Arizona	$ 46,046,334	$ 394,805,521
California	125,023,848	5,531,400,000
Colorado	3,180,212	361,608,819
Idaho	3,804,236	187,200,000
Montana	9,328,087	170,900,000
Nevada	2,469,534	135,800,000
New Mexico	24,094,905	342,200,000
Oregon	1,475,816	585,700,000
Utah	14,990,808	274,900,000
Washington	273,784	1,203,200,000
Wyoming	8,088,042	99,200,000

Source of data: Sample survey of county tax assessors conducted by the Division of Economic and Business Research, The University of Arizona, and various state financial reports.

D. WESTERN MINERALS AND THE PACIFIC BASIN

1. Western States Mineral Exports

In the postwar period from 1947 through 1967, the mines of the 11 Western States produced an output of nonfuel minerals valued slightly in excess of $35.7 billion. Of this total, over $530 million worth (less than two percent) was exported through West Coast ports. The demand of the Pacific Basin countries for western mining outputs thus has represented but a small percentage of the relevant total demand for those outputs. The composition of this Pacific Basin demand for western minerals, however, reveals its importance both to the countries lacking the particular nonfuel minerals they find necessary to import and to the specific western groups and geographical areas involved in the mining of these specific minerals.

Total United States exports of all goods to the Pacific Basin countries from 1961 through 1966 approximated $23.6 billion. During that period, about 1.5 percent of total Western States mining output was exported to these countries as raw mineral commodities, valued slightly in excess of $208 million. Western mineral exports to those countries therefore represented less than one percent of all domestic exports to that region.

The composition of Pacific Basin minerals demand, however, is extremely important. Arizona has been supplying molybdenum concentrates in especially large quantities for export. Together with Colorado and Utah, Arizona exported $55 million of this commodity in 1966, an increase of one-third over the 1960 export level for molybdenum concentrates.

California is an important exporter of iron ore, boron minerals, and diatomite. In 1966, total mineral exports from California were valued at approximately $77 million, of which diatomite exports represented $11 million. Iron ore exports climbed from a level of $1 million in 1960 to $25 million in 1966, due to greatly increased sales to Japan.

Idaho, along with Utah, Montana, and Wyoming, normally exports large quantities of phosphate rock. These states, combined, exported $14 million of this mineral in 1966, double the quantity exported in 1960. Montana's leading exports, however, are the primary metal products, although the levels of these products sold fell off somewhat around the mid-sixties. Nevertheless, the state is the second largest United States exporter of phosphate rock.

Nevada's mineral exports were estimated at $9 million in 1966, with iron ore exports accounting for about $5 million (compared to $1 million in 1960). Roughly 90 percent of all Nevada's production of iron is normally exported. The state is also the nation's leading producer of magnesite, and it accounted for more than half of total national sales ($7.8 million worth in 1966) of that mineral. Nevada also contributed to the supply of diatomite exported by the United States.

New Mexico exports primary metals, potassium, and other minerals. Ninety percent of the nation's production of marketable potassium salts is produced in that state.

Utah's primary exports consist of basic nonferrous metal products and phosphate rock, but the rate of expansion of these exports since 1960 has been rather slow. Washington, too, is a major supplier of primary metals. Nonferrous metals, primarily refined copper and unwrought aluminum, have accounted for about 75 percent of the state's primary metal exports in recent years. Industrial minerals have been the major mineral export product of Wyoming, however. In 1966, the state exported an estimated $6 million of bentonite, most of the nation's exports of that commodity. Exports of sodium carbonate are also important to Wyoming.

The principal nonfuel mineral exports going through West Coast customs districts in the years 1947 to 1967 (given in Table 6) well exceeded $500 million. Of particular significance were the exports of iron ore (nearly $238 million), diatomaceous earth ($46 million), miscellaneous nonmetallic minerals (almost $42 million), molybdenum concentrates (nearly $36 million), copper ore and concentrates (more than $24 million), salt (almost $24 million), and magnesite (about $23 million).

There has been significant growth in the export of minerals from the Western States since the end of World War II. Iron, molybdenum, and copper ores, as well as diatomaceous earth and magnesite, have been those products in which the growth has been most noteworthy. The dollar values of sales of these products in the 1958-1967 period were usually much more than 300 percent over the 1947-1957 period totals. Salt exports also saw significant growth, increasing by about 250 percent in the second decade since World War II.

The sources of Pacific Basin demand for the outputs of the Western States' mineral industries are expressed in general terms in Table 7. Japan has represented about half of the area's demand for American mineral exports. A fourth has gone to Australia and the Philippines. The situation in mineral exports has in fact been rather similar to that of total exports, in spite of the fact that Australia represents a competitor for United States mining exporters as well as a source of demand. Only a few countries in the Pacific Basin have been insignificant importers of this nation's mining products.

Japan's "economic miracle" since 1945 has made that country the United State's chief trading partner in the Pacific Basin. Economic growth there has been extremely rapid and it has occurred in spite of an inadequate domestic mineral base. Approximately half of the foreign market that exporting industries face in the Pacific have been in that single country. In the period from 1946 to 1965, the annual rate of expansion of American exports to Japan was more than 12 percent, compared with the rate of growth of all United States exports of less than six percent each year.[21]

A significant part of the Japanese import demand is for metals and minerals, for Japan cannot supply its own needs from its own limited mineral resources. Since 1960, Japanese domestic production of iron and steel nonferrous metals, ceramic stone, and clay products have all increased by more than 50 percent. Copper, lead, zinc, tin, aluminum, and nickel production from imported ores have also increased somewhat in recent years. Australia, however, is now providing greater competition to the United States in supplying Japan's metal and mineral demands.

Nevertheless, the need for continued importation of American mining outputs is not likely to abate soon. Japanese mineral resources are becoming exhausted and have been rather heavily exploited. A survey taken in 1962 established that only 41 million tons of exploitable domestic iron ore remained available for Japanese industry.[22] The principal mineral exports from the United States to Japan have been metalliferous ores and metal scrap, including zinc, aluminum, aluminum base alloys, copper, copper base alloys, nickel, nickel base alloys, molybdenum concentrate, nonferrous metal scrap, and iron and steel (ores, concentrates, and scrap).

On balance, *Australia* is an exporter of minerals, and the country is in a strong position to compete with United States exports in the mineral markets of the Pacific Basin. There are certain mineral products, however, that Australia imports from the United States. Among these are copper and copper alloys, iron and steel, and other miscellaneous metals, as well as crude fertilizers. Australia's economy is faced with a manpower constraint, but has great natural resources. The nation's potential for growth is probably very great, and rich mineral deposits will undoubtedly be a central factor in the development of impressive economic capacity as some of Australia's Far Eastern neighbors (especially Japan) begin to provide a greater abundance of (especially skilled) labor. These additional workers will in turn create a larger domestic market for Australia's industrial output, acting as a catalyst to future economic expansion.[23] Australia's trade in minerals is even now an important element of that country's total economic activity.

Western States minerals have played no significant role in development in *Indonesia* in the post World War II period, though there have been some sales of fertilizers, iron, and steel. Potitical instability in Indonesia has been expressed by extreme nationalism, expulsion of the Dutch in 1957, and general hostility toward foreign investments. Economic instability has been demonstrated in hyperinflation, in declining exports of rubber, petroleum products, and most other traditional export commodities, and in restrictions on imports as an upshot of the loss of foreign exchange. Conditions have befun to improve in

Table 6

DOLLAR VALUE OF MINERAL EXPORTS THROUGH WEST COAST CUSTOMS DISTRICTS 1947-1967

Commodity	1958-1967	1947-1957	Total
Natural fertilizer of mineral or vegetable origin (including natural sodium nitrate)	1,316,621	821,047	2,137,668
Natural potassic salt fertilizer, crude	6,043,516	3,114,219	9,157,735
Sand, except metal-bearing sand	1,909,235	199,928	2,109,163
Building and monumental stone, rough	404,142	183,562	587,704
Gravel (including crushed or broken stone)	2,674,019	44,973	2,718,992
Industrial diamonds (including crushing bort)	4,098,333	35,729	4,134,062
Natural abrasives (emory, etc.)	129,573	12,733,764	12,863,337
Gypsum, crude (including gypsum plasters)	2,135,875	825,490	2,961,365
Natural asphalt and bituminous, unmanufactured	3,361,842	1,333,955	4,695,797
Phosphate rock (fertilizer material)	316,490	133,721	450,211
Crude sulfur	635,142	557,810	1,192,952
Dust and powder of natural or synthetic stones	3,392,744	9,337	3,486,081
Fire clay and bentonite clay (including calcined)	3,958,467	156,988	4,115,455
Natural phosphate fertilizers, m.e.c.	231,686	290,123	521,809
Limestone flux (including dolomite)	1,963,711	475,880	2,439,591
Sulfur, n.e.c. (including iron pyrites)	244,596	980,359	1,224,955
Diatomaceous earth	46,336,440	*	46,336,440

(continued)

Table 6 (continued)

Fullers earth (including clays)	3,769,092	*	3,769,092
Asbestos, crude and spinning fibers	771,387	538,000	1,309,387
Iron ore and concentrates	187,771,116	49,721,332	237,492,448
Kaolin clay	650,698	16,832	667,530
Magnesite, dead burned	21,493,238	1,528,354	23,021,592
Asbestos, non-spinning fibers	9,601,235	168,852	9,770,087
Copper ore and concentrates (including matte)	23,586,681	648,397	24,235,078
Kayanite	42,738	146	42,884
Magnesite, n.e.c.	3,246,990	232,966	3,479,956
Asbestos, waste and refuse	4,354,956	135,592	4,490,548
Mica - waste, scrap, and ground	202,347	32,475	234,822
Natural talc, etc.	2,419,716	1,325,675	3,745,391
Bauxite and aluminum concentrates (excluding aluming)	375,491	10,542	386,033
Natural graphite	138,340	23,832	162,172
Salt (including table salt), n.e.c.	16,917,517	6,844,877	23,762,394
Nonmetallic minerals (including feldspar)	41,671,818	*	41,671,818
Manganese ore over 10 percent Mn	67,396	13,627	81,023
Tantalum ore and concentrates	68,933	*	68,933
Sodium sulfate (crude and refined)	4,999,447	3,348,811	8,348,258
Molybdenum ore and concentrates	27,589,608	7,966,748	35,556,356
Tungsten ore and concentrates	50,010	57,825	107,835
Zirconium ores and concentrates	17,509	178	17,687
Fungicides	1,494,111	1,326,790	2,820,901

(continued)

Table 6 (continued)

Ores and concentrates and nonferrous base metals	1,206,194	57,562	1,263,756
Platinum and platinum group ores	2,389,072	0	2,389,072
Vanadian ores and concentrates	1,764,115	0	1,764,115
Uranium ores and concentrates	113,420	0	113,420
			531,995,905

*Included under other classification

Source of data: U.S. Department of Commerce

recent years, however, and there may be grounds for anticipating that the products of western mines might have a role to play in that country's future.

The development of the *South Korean* economy has been rather heavily dependent upon United States development assistance. Future development of the Korean economy will be facilitated, as it has in the past, by access to the mineral resources of the Western United States. The Republic of Korea has already imported significant quantities of iron and steel products, phosphatic fertilizers, and ferrous scrap from the United States.

Malaysia is another Pacific Basin country that has been struggling with the problems of economic modernization. It has received considerable assistance from the United States, and this nation has also made extensive purchases of Malayan rubber and tin. Because exports usually represent from 40 to 50 percent of that country's economic activity, and because rubber and tin are by far the most important exports, the United States market is of obvious importance to Malaysia. More to the point, however, is the importance of the Malaysian market for Western States mineral outputs, especially fertilizers. This market represents an important source of demand for Western mines, and these minerals are, in turn, indispensable to Malaysian development.

For various reasons, the security and, therefore, the economic development of *Formosa* have been important to the United States. Foreign aid and good trade relations alone have not been responsible for the economic performance of the beleaguered island thus far. The mines of the Western United States have contributed both worked and unworked iron, steel, copper, lead, nickel, and alloys that have been needed in Formosa's development effort. That country will doubtless continue to provide a growing demand for the minerals of the Western States.

One of the basic industries of *New Zealand* is metal processing, the inputs of which are mostly imported. Iron and brass founding represent the largest branch of such production, but diecasting, smelting, and the refining of lead and other nonferrous metals, as well as copper wire drawing and fabrication, are also important to the New Zealand economy. In 1964, 1965, and 1966, the United States exported more than $8 million, almost $9 million, and over $12 million worth of crude mineral materials to New Zealand, respectively. This represented, on the average, about 10 percent of that country's imports from the United States.

Although Japan and Australia have made significant inroads in recent years, the United States remains the principal trading partner of the Philippines, as well as one of that country's main sources of iron, steel, and nonferrous metals. In 1937, almost three-fourths of total Philippine iron and steel imports came from the United States. By 1953, however, the United States' share of that market had declined to less than 50 percent. Of the nonferrous metals imported by the Phillippines in 1953, 75 percent of the total came from the United States. Of total Philippine imports of base metals in 1962, the proportion from the United States was down to 26 percent.

E. SUMMARY

The nonfuel mineral industries have had a definite, though changing impact upon the economic environments in which they operate. Since World War II, the role of nonfuel minerals in directly providing employment and personal income has been relatively small in relation to the national economy as a whole. While at times the relative contribution of the nonfuel mineral industries to employment and income has increased, it has occupied a rather steadily declining share of the national economic picture. In absolute terms, however, the nation's nonfuel mineral industry employment and the personal income derived therefrom have been increasing.

Of far greater significance to the economy of the United States have been the physical products of the nonfuel mineral industries, their outputs of metals and industrial metals. These products have provided substantial inputs to a large segment of the nation's manufacturing activity, as well as most of the country's construction industry, thus providing a major part of the raw materials base upon which the domestic economy rests. In addition, these commodities have been exported in significant amounts and thereby have contributed toward a favorable balance of international trade.

Even though of vital significance in the national economic environment, the metals and industrial minerals produced from the public lands of the United States have been of even greater local and regional significance in the Western States. In many areas of the West, the direct contributions of nonfuel minerals to employment and income have been substantial and have increased dramatically since World War II. The secondary effects of recirculated income have been much greater, particularly in those states with diverse economies such as California, Colorado, and Washington.

The contributions of nonfuel minerals production activity to the public sector of the economy have also varied but have generally increased since 1947. In relative terms, the importance of net revenues from the mineral industries have been far greater at the state and local level than to the federal government. At all levels of government, the major contributions to the public sector have been through taxes, including both net and gross income taxes and property taxes. Expenditures for the benefit of the mineral industries have been greatest at the federal level, but relatively small at all levels of government.

The economic development of both the Western States themselves and the countries of the Pacific Basin apparently has had a significant impact upon the development of mineral resources on the public lands. There has been a particularly strong relationship between overall industrial development in the West and the production of *industrial* minerals. The production of *metallic* minerals in the West has more often been a cause of local and regional economic development than a result. The postwar development of the Japanese economy has had a significant influence on western metals production.

Table 7

MINERAL EXPORTS FROM THE UNITED STATES TO PACIFIC BASIN COUNTRIES 1967

Commodity and Destination	Value
Natural phosphates	
Japan	$18,427,444
Australia	5,632,907
Republic of Korea	1,576,607
New Zealand & Western Samoa	1,415,308
Philippines	1,322,116
Malaysia	170,797
	$28,545,179
Sulfur, crude and refined	
Australia	8,541,485
Taiwan	4,417,684
New Zealand & Western Samoa	2,461,997
Thailand	855,625
Republic of Korea	280,625
Philippines	242,332
	$16,799,748
Natural abrasives NEC including diamond dust	
Japan	3,338,221
Australia	946,184
Philippines	210,759
	$ 4,495,164
Clay and other refractory minerals NEC	
Japan	3,672,161
Australia	2,018,019
Philippines	383,813
New Zealand & Western Samoa	154,059
Hong Kong	129,482
	$ 6,357,534
Sodium chloride or salt	
Japan	$ 2,098,510
Iron ores and concentrates	
Japan	$42,178,715
Iron and steel scrap	
Japan	174,075,544
Republic of Korea	14,618,502
Taiwan	3,658,681
Thailand	379,700
Philippines	289,401
Hong Kong	213,908
	$193,235,736

(continued)

Table 7 (continued)

Copper ores and concentrates, including matte	
Japan	$10,002,785
Nonferrous metal ores and concentrates, NEC	
Japan	6,424,490
Australia	268,714
	$ 6,693,204
Nonferrous metal scrap, except zinc scrap	
Japan	37,088,551
Taiwan	791,584
Australia	200,553
Republic of Korea	149,721
	$38,230,409
GRAND TOTAL	$348,636,984

Source of data: U.S. Bureau of the Census, *Exports of Domestic Merchandise by Country of Destination and Method of Transportation*, Dec. 1967.

FOOTNOTES

14/ U. S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1957,* Washington, D. C. (1960), p. 74.

15/ *Ibid.*

16/ U. S. Bureau of Labor Statistics, *Employment and Earnings.*

17/ *Personal Income by States,* a supplement to the *Survey of Current Business,* by Chester F. Schwartz and Robert E. Graham, Jr., National Income Division, Office of Business Economics, 1956 edition, Washington, D.C. (1956).

18/ U. S. Department of Commerce, *Annual Survey of Manufactures,* 1966.

19/ *U. S. Trade Balance with Japan,* U.S.-Japan Trade Council, ACC No. 104 (1967), p. 149.

20/ *Ibid.*

21/ John McEwen, "Trade With Asia," *Far Eastern Economic Review,* May 23, 1968.

22/ *Ibid.*

23/ McEwen, John, "Trade with Asia," *Far Eastern Economic Review,* May 23, 1968.

CHAPTER 12

MINERALS AND THE PHYSICAL ENVIRONMENT

Have the nonfuel mineral industries had any measurable effects upon the various aspects of their physical environment?

A. MINERALS AND WATER RESOURCES

1. Water Utilization by the Mineral Industries

Water has been a critical factor in the mineral industries of the Western United States since the day that the water in Sutter's Millrace concentrated native gold from gravel and caused what has become known as the California Gold Rush. In the working of the early placer deposits in California and elsewhere in the West, running water was the principal means of separating valuable mineral from waste. Water under pressure became the means of excavation in the hydraulic mining of placers. Water sloshed around in a miner's pan was a principal component of both early exploration and early beneficiation. Even the mules that turned the grinding wheels in the early processes of amalgamation required water.

The ready availability of running water in surface streams was a major factor in the early development of placer mines in California, Montana, Idaho, Colorado, Oregon, and Washington. The absence of such water supplies was a significant deterrent to the development of other gold-bearing gravels in the more arid regions of the West. Today, although gold-bearing sands and gravels still occur in parts of the Southwest, the absence of sufficient water has prevented their commercial development as placer mines.

Throughout the history of nonfuel mineral production in the Western United States, water has played an important role. It has been used in a variety of ways for a variety of purposes, and it has come from a variety of sources. Although generally reliable data are unavailable for any time prior to 1954, it has been estimated that since 1900 the use of water in the mineral industries has doubled about every 25 years. At the present rate of increase in water utilization, it is expected that water requirements will double again between now and 1985.[24]

Prior to the early 1950's, while the availability of water of adequate quality was generally well recognized as a problem throughout the mineral industry itself, it was not recognized as a serious problem for other water users. Since the initial study in depth of water requirements and utilization in the mineral industries in the 1954 *Census of Mineral Industries*, however, numerous studies pertaining to water resource utilization by mineral production activities have been made. Specific information on mineral and water resources is therefore available only for the period from 1954 to date.

The Western States in recent years have drawn more than half of the new water used in the mineral industry.[25] Of the two percent of all industrial water used by the mineral industries, the processing of natural gas, phosphate rock, sand and gravel, and iron ore account for the greatest water use. In 1960 it was estimated that the total water used by industry in the United States was 99 trillion gallons annually, not including that amount used to generate hydroelectric power. Of the total volume of industrial water in the nation, 94 percent was used for cooling, but this is not true for the mineral industries. Furthermore, of the 99 trillion gallons of water used annually for industry, approximately 85 percent was used in the Eastern States. In contrast, more than half of the new water normally used in the mineral industries has been in the West.

In the 1960's, of the new water withdrawn through self operating systems in the mineral industries, about 40 percent has been obtained from streams or rivers, 30 percent from groundwater sources, and about 20 percent from lakes or reservoirs. More than three-fourths

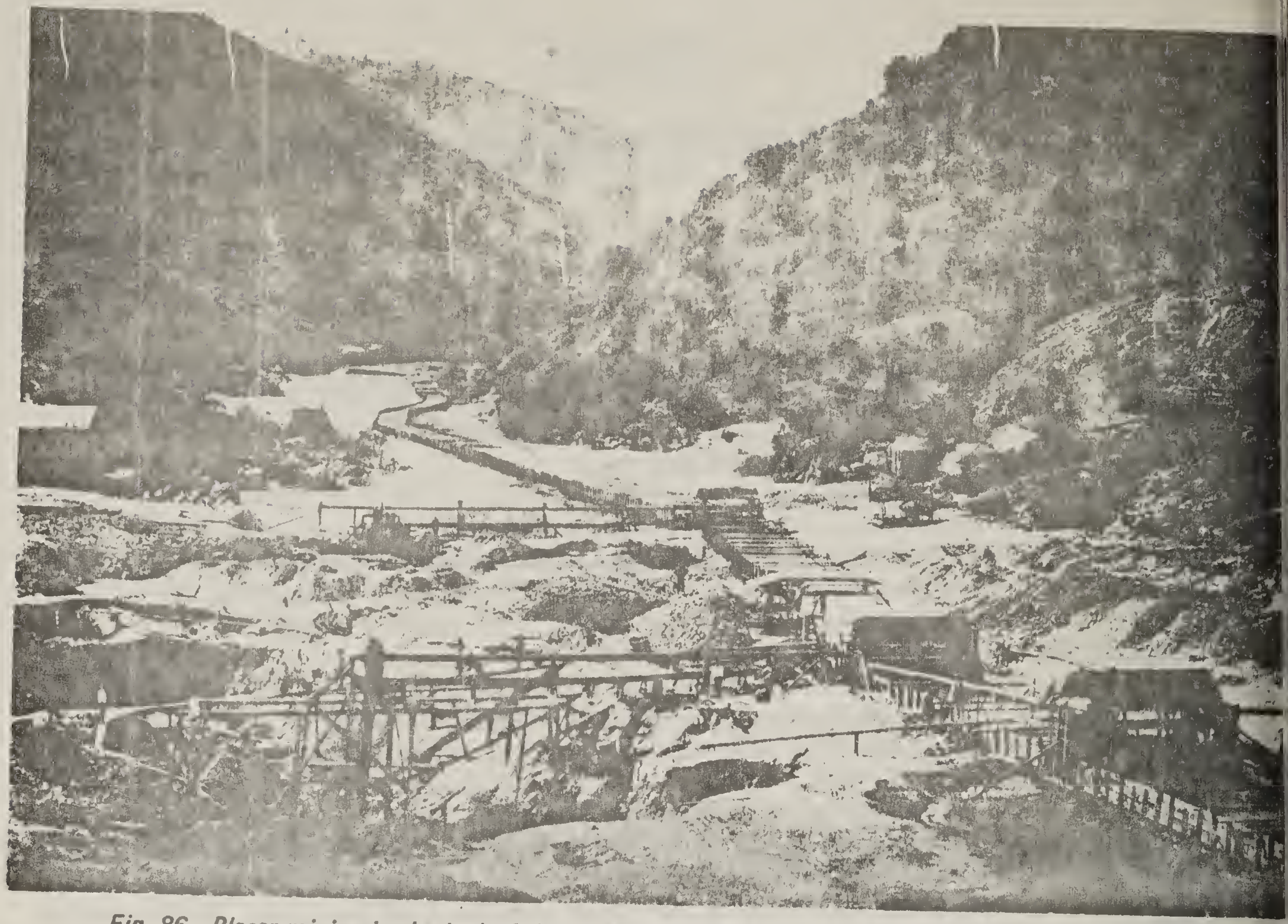


Fig. 86 - Placer mining in the bed of the American River in California in 1859 used large amounts of water directly from the river. The channeled river, in fact, became the principal beneficiating agent. In areas where abundant water did not exist, placer deposits were not worked.

of this latter amount is normally contaminated before the mineral industrial makes use of it. On the other hand, 85 percent of the groundwater used is usually fresh. Of the water supplied from streams or rivers slightly more than half has been fresh water while slightly less than half has been contaminated by other users, and about one percent has been slime in content, i.e., contaminated by nature. The source and character of new water used by the mineral industries in 1962 is shown in Table 8.

Of the more than 900 billion gallons of new water intake required by the mineral industries in 1962, almost 85 percent was redischarged for the use of other water users, and the remaining 15 percent was consumed, either through evaporation or through incorporation in the product. Of the more than 760 billion gallons discharged, more than three-fourths was discharged to the surface, a little less than 20 percent went into the ground, one percent was discharged to sewers, while three percent was transferred directly to other users.

More than 35 percent of the mineral industries' new water intake in 1962 was derived from subsurface sources, but only about 15 percent was discharged back into the ground. Most of the groundwater discharge occurred as seepage from tailings ponds. Table 9 shows the water discharge by type of discharge and by state for the mineral industries in 1962. Of the total new water used by the mineral industries in the United States in 1962, 53 percent was classified as fresh water, 44 percent had been previously contaminated, and three percent was saline.

Water use in the mineral industries has varied by commodity, by the type of process used, and by the stage of mineral production. Of the total water consumed, by far the

Table 8

SOURCE AND CHARACTER OF NEW WATER USED BY THE MINERAL INDUSTRIES, 1962[1]

	Millions of Gallons Per Year			
Source of Water Withdrawn	Fresh	Saline	Contaminated	Total
Self-Operating Systems				
Stream or River	187,196	4,370	160,456	352,022
Lake or Reservoir	37,763	27	151,913	189,703
Ocean Estuary	–	15,150	--	15,150
Ground Water	229,046	6,785	33,974	269,805
Mine Water	6,294	1,675	51,889	59,858
Total Withdrawn	460,299	28,007	398,232	886,538
Purchased From Others	16,630	9	164	16,803
Transferred From Others	378	420	1,759	2,557
Sewage Effluent	–	–	–	2,416
Total New Water	447,307	28,436	402,571	908,314

[1] Includes natural gas processing plants but excludes petroleum and natural gas producers and mineral producers using less than one million gallons annually.

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries,* U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D. C., 1966.

Table 9

WATER DISCHARGE BY THE MINERAL INDUSTRY, 1962

			Discharged, Millions Gallons/Year		
	Surface	Ground	Sewer	Transferred	Total
Arizona	2,283	10,768	721	24	13,796
California	49,594	13,148	460	586	63,788
Colorado	5,403	2,194	72	136	7,805
Idaho	1,584	671	221	7,215	9,691
Montana	4,685	3,990	124	81	8,880
Nevada	129	4,912	140	16	5,197
New Mexico	356	4,556	163	215	5,290
Oregon	2,101	627	3	2	2,733
Utah	4,011	3,932	2,250	167	10,365
Washington	6,763	665	38	–	7,466
Wyoming	755	2,122	116	10	3,003

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries,* U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D.C., 1966.

Table 10

WATER USE IN THE MINERAL INDUSTRY BY TYPE OF OPERATION

	Water - Millions of Gallons Per Year					
	New	Recirculated	Total	Discharged	Consumption	
Underground Mines	84,131	152,846	236,977	68,475	15,656	53
Surface Mines	426,304	580,410	1,006,714	354,686	71,618	134
Mills, pre. Plants	327,098	1,752,090	2,079,188	279,556	47,542	200
Chemical or Solution	16,267	3,588	19,855	9,941	6,326	200
Pet. & Nat. Gas Prod.	121,538	74,112	195,650	10,960	110,578	67
Other	55,058	253	55,311	50,213	4,845	383
Total	1,030,396	2,563,299	3,595,695	773,831	256,565	138

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries,* U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D. C., 1966.

greatest consumption has been in petroleum and natural gas production. In the nonfuel mineral industries, surface mines and mills and other beneficiation plants have been the greatest users, as shown in Table 10. The amount of water consumed by the mineral industry depends, of course, on a number of variables. It depends on the quantity of water that can be recirculated, the temperature and humidity of the area in which the utilization takes place, and the proportion of the water that is used for cooling and condensing. Because of evaporation, and because in some processes water becomes an actual part of the finished product, consumptive uses of water cannot be eliminated simply by recirculation. It should be pointed out, however, that in the mineral industries a relatively minor amount is used for cooling and condensing as compared to such uses in other industries.

Much of the total water used by the nonfuel mineral industries requires initial treatment in order to obtain a water quality compatible with the specific mineral production process involved. The industry's discharge water, on the other hand, is usually treated either as a public service or because of the quality standards for plant effluent imposed by state or local governments. Frequently, in many mineral processing operations, there is no effluent, however, because most of the water is recirculated as an economy measure, and because in many instances it still contains valuable components and in effect becomes part of the process flow. An example of this participation of water in the minerals production process is shown in Figure 87.

The major methods of treating water in the mineral industries before its mineral processing use have been through acidity or alkalinity control, settling to remove solid particles, treatment to remove organic material, and chlorination. Approximately one-third of the water taken in by the mineral industries must be treated for acidity or alkalinity because these are important in most minerals beneficiation and advanced processing. Settling is a treatment applied to about one-fifth of the water used by the mineral industries because foreign solid particles can also hamper minerals beneficiation and more advanced processes. Attempts to suppress organic material and bacteria (including chlorination) are used on about 25 percent of all the water taken in by the nonfuel mineral industries. Most

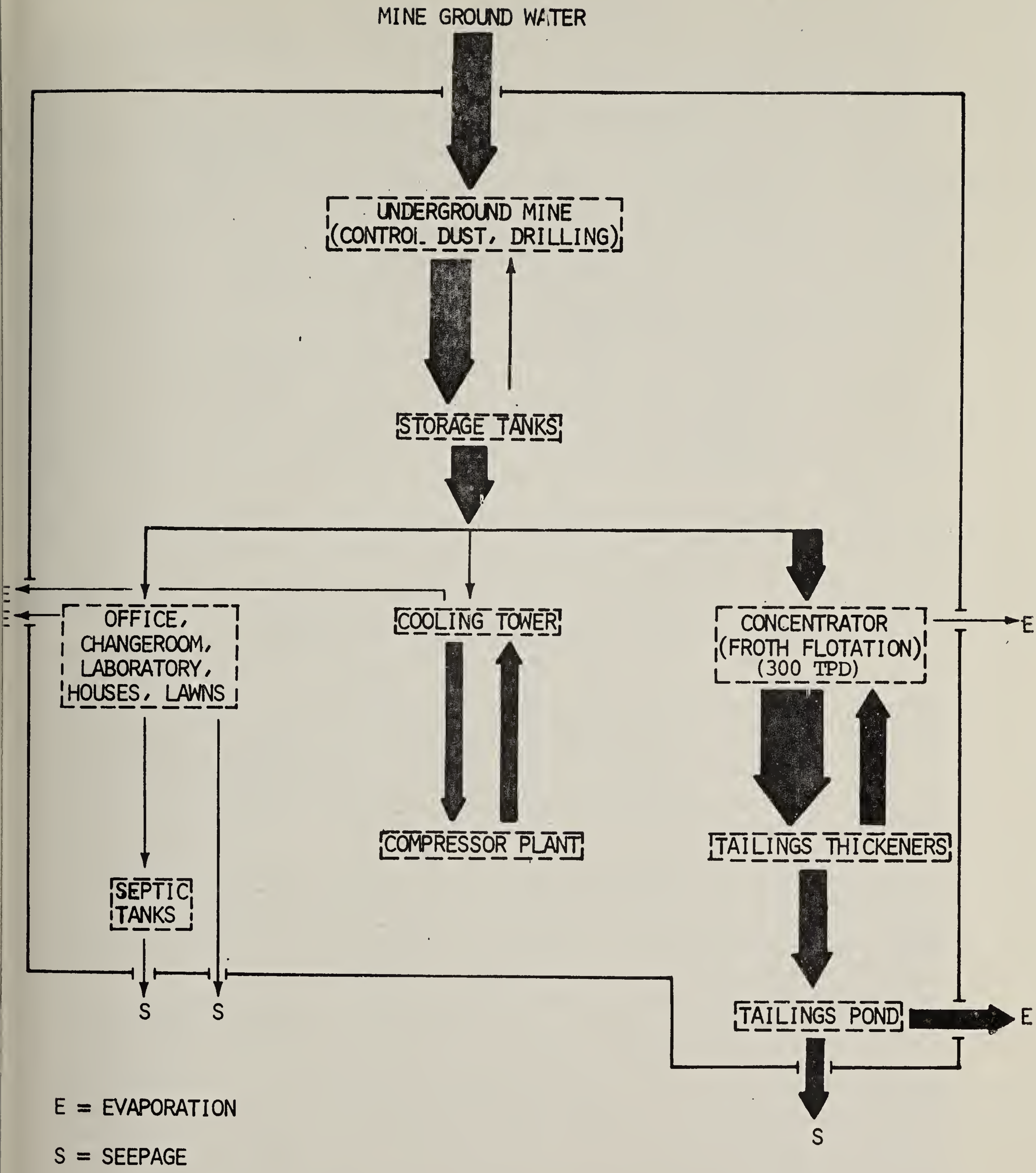


Fig. 87 - Typical water flow system for nonfuel minerals mining and beneficiation operation in the Western United States.

new water is subjected to filtration, settling, and bacterial treatment, whereas recirculated water is usually subjected only to acidity control and settling. The major technique used for the treatment of discharge water is settling.

By the mid-1950's, water was still a significant component in the mining of gold in the United States. In 1954, placer gold mining operations in the contiguous United States used more than 16 billion gallons of water including recirculated water. Of this, 80 percent came from producer-operated surface water systems while another 17 percent came from combined surface and groundwater systems also operated by the mineral producing companies. Active placer operations in Alaska added another 50 billion gallons to this total. Of the 16 billion gallons used by placers in the Western United States, less than half was actually used. The remainder was taken in and almost immediately discharged. Because of the nature of placer gold operations, particularly where there is a preponderant use of surface water such as in creeks, rivers, other streams, and in lakes, the industry's water discharge from sluicing and washing operations is approximately the same as its water intake, and the drainage of mine-generated water is negligible. Surprisingly, lode gold mining (or hard-rock gold mining) had also been a substantial user of water. In 1954, hard-rock gold mining operations in the United States had a gross water use of about seven billion gallons. Of this, however, less than 500 million gallons were actually consumed and more than three billion gallons were discharged. Most of the water usage in gold mining has been in beneficiation, where not quite seven billion gallons were used in 1954 in both beneficiation and advanced processing. The greatest amount of water consumed, however, was in those plants which used amalgamation. Most of the water used by gold mining operations in the United States in 1954 was used in California, where dredging operations in the central valley were active.

Silver production was far less a user of water in 1954 than was gold mining and beneficiation. In that year, producing silver mines in the United States had a gross water use of a little over two billion gallons. Most of this was used in beneficiation plants that utilized froth flotation for the separation of silver minerals from gangue. An extremely high percentage of this water usage by the silver industry occurred in Idaho.

The production of mercury, long associated with both gold and silver production, has been a far less important user of water than either of those two metals. In 1954, domestic mercury producing operations used a total of only 12 million gallons of water. Of this only two million gallons were actually consumed in the mercury production process. All of this usage was in the Western United States. Unlike many other mining and beneficiation operations, a significant portion of the water used in mercury production is used in cooling.

At the Cordero Mining Company property in Humbolt County, Nevada, new water for production operations and for associated domestic uses is pumped from the mine itself as well as from a 600-foot deep well located near the mine. Cold water is pumped from the mine at the rate of 20 gallons per minute, while 10 gallons per minute of hot water are pumped from the well. An additional 10 gallons per minute of new water is obtained by the condensation of water evaporated from the mercury ore itself in the drying section of the multiple hearth type furnace used in the advanced processing operations. Approximately 20 gallons of water per minute are required to cool the production plant condenser pipes and to wash the accumulated mercury-laden dust into the condenser system.

Water loss through evaporation is about 10 gallons per minute and seepage occurs at about the same rate. An estimated two gallons per minute is used underground for rock drilling operations and is considered consumed. The mine townsite, which consists of about 35 homes, an office, a bunkhouse, a cookhouse, and the mine change house, uses about 18 gallons per minute of new water. The 10 gallons per minute low of hot well water is used exclusively for these domestic purposes, and it is augmented by eight gallons per minute of cold mine water. Water generated on one particular level of the mine is pumped to the surface at a rate of 550 gallons per minute, but this water is not used in the mercury-producing operation. Instead, it is allowed to flow into an adjoining valley where it is used for agricultural and stock watering purposes.

On balance, the mercury producing operation at Cordero has an intake of 40 gallons of

Table 11

WATER USAGE BY MAJOR NEVADA MINERAL INDUSTRIES, 1962

Mineral Commodity Production	New water million gallons	Reused water (recirculated and transferred) million gallons	Total usage, new, recirculated, and transferred: Million gallons	Total usage, new, recirculated, and transferred: Gallons per unit of production	Consumption million gallons
Copper	7,042	2,868	9,910	60g/lb	2,937
Lead-zinc	3	--	3	2g/lb	–
Gold	375	200	575	23,839g/oz	123
Iron	15	213	228	1,400g/ton	7
Mercury	6	--	6	933g/flask	3
Barite	2	50	52	11,800g/ton	1
Diatomite	141	–	141	1,400g/ton	28
Gypsum	64	150	214	950g/ton	36
Magnesite	83	21	104	190g/ton	48
Sand and gravel	604	315	919	126g/ton	72
Total	8,335	3,817	12,152	--	3,255

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries,* U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D.C., 1966.

water per minute. Of this, 13 gallons per minute are lost by evaporation while seepage accounts for the discharge of the remaining 27 gallons per minute. Virtually nothing is consumed in the product itself. The uses for the water include cooling and washing in the advanced processing operations, drilling in mining operations, and domestic uses. The operation also generates an additional 550 gallons per minute (more than 10 times its own intake and more than 40 times its own actual consumption rate) for other users, primarily agricultural.[26]

Mercury has been one of the smallest users of water in the state of Nevada, and the production of the liquid metal has also been a minor water user elsewhere throughout the West. The nonferrous base metals, copper, lead, and zinc, however, have also been relatively minor consumers of water. Although large amounts of water are involved in the production of these metals, actual consumption is relatively slight, with most of the water recirculated time and time again and with losses to evaporation the primary reason for actual water consumption. The comparative uses of water by the various mineral industries in Nevada in 1962 are shown in Table 11.

An example of recent water use by moderate sized operations is provided by the Silver King Mines in White Pine County in Eastern Nevada where, in 1962, a combined lead-zinc-silver-copper ore was being produced on a moderate scale from both open pit and underground operations. The producer employed a selective froth flotation concentrator which yielded both a silver-lead concentrate and a copper-zinc concentrate. New water for the mining operations was obtained from springs in the immediate mine area. About 800 gallons per day were used for dust control in the open pit and in drilling operations both in the pit and underground. An additional 1,650 gallons a day were pumped from the underground mine and allowed to discharge as waste at the surface. Water from nearby hot springs was pumped approximately one-quarter of a mile to the concentrator plant. The beneficiation plant in general requires a total flow of approximately 150 gallons per minute of water. Of this, about 25 gallons per minute were lost by evaporation. The remaining nearly 125 gallons per minute were returned to the environment through seepage. A negligible amount of water was used for domestic purposes in the mine office and plant. Most of the evaporation loss (96 percent) occurred from the tailings pond, which covered about five acres. Only one gallon per minute was lost through evaporation during the actual concentration process using the differential floation of the ore minerals. This small proportion of total usage is typical of many base metal sulfide mining and beneficiating operations.

Similar conditions, although on a much grander scale, are found throughout most of the nation's copper industry. At Yerington, in Lyon County, Nevada, the Anaconda Company has an open pit copper mine producing both oxide and sulfide ores, a concentrator using froth flotation methods, a sulfuric acid plant, a leaching operation, and a precipitation operation producing cement copper from leach solutions. The operation also involves a townsite with a population of about 1,100 that is maintained by the company. New water for the requirements of the entire mineral producing operation and associated activities is obtained from seven wells in the immediate vicinity of the open pit mine, three wells in a valley near the concentrating plant, and one well near the leaching plant. These 14-inch diameter wells average 600 feet in depth, even though a relatively high water table exists in the vicinity of the mine. This near-surface water table necessitates rigid pumping control to prevent flooding or excessive seepage in the open pit operation. The prevention of flooding in the mine is accomplished by priority pumping from the seven wells near the pit itself. This pumping is done at a rate considered sufficient to maintain the surrounding water table 100 feet below the lowest point in the pit. Thus, just as in early mining operations, many of the considerations involved in water utilization in the mineral industries today are involved with keeping water away from the mine workings as well as acquiring additional water.

The water requirements of the operation at Yerington vary depending upon the stage of processing. In the open pit, water requirements include about 40 gallons per minute for drilling and dust control. Of this, approximately 25 gallons per minute evaporate and are lost, while the remaining 15 gallons per minute are allowed to drain to a nearby river. In the beneficiation plant, crushing and agglomeration operations require approximately 155 gallons per minute of new water. Most of this total, however, is subsequently transferred to the leaching operation and is not allowed to discharge at all. The remainder of the leaching solution requirements is obtained at about 145 gallons per minute from new water sources and 770 gallons per minute of waste water from the sulfuric acid plant operation.

Evaporation during leaching operations and from the beneficiation plant's tailings is estimated at 320 gallons per minute. The cement copper precipitation plant has an intake of 750 gallons per minute of copper bearing solutions which are transferred from the leach plant. To this is added nearly 80 gallons of new water per minute. Evaporation in the process is estimated at a little more than 80 gallons per minute, while two gallons per minute are incorporated in the precipitate itself as entrained water. The total of almost 745 gallons per minute of spent leach solution is used to sluice calcines from the sulfuric acid plant reactor to the calcine evaporation area. Most of the cement copper plant solvent is recycled at a rate of almost 2,500 gallons per minute. New water requirements for the operation's sulfuric acid plant are almost 1,000 gallons per minute, and two gallons per minute of this comes from the ore itself. Evaporation losses are nearly 180 gallons per minute, and about 45 gallons per minute are lost from the process through seepage to the environment. As mentioned, about 770 gallons per minute are discharged directly to the leach plant.

For the concentrator, total water intake is at a rate of 2,900 gallons per minute. This includes both new and recirculated water. Of this, the new water is taken in at a rate of 900 gallons per minute and this includes 160 gallons per minute directly from the main water supply, 50 gallons per minute from the ore itself, and 690 gallons per minute from the

Table 12

MONTANA NONFUEL MINERAL INDUSTRY WATER USAGE, 1963

		Water usage (gallons per unit of production)					Value of product (dollars per 1,000 gallons water)				
Mineral Industry	Unit	New	Recir-culated	Total require-ments	Con-sumed	Dis-charged	New	Recir-culated	Total require-ments	Con-sumed	Dis-charged
Metals:											
Aluminum	Ton[b]	10,577	5,125	15,695	2,177	8,400	$45.3	$93.2	$30.6	$220.6	$57.8
Copper	Ton[c]	116,488	128,868	245,356	35,636	80,852	5.4	4.1	2.2	17.1	7.6
Lead	Ton[c]	9,737	---	9,737	1,276	8,460	---	---	---	---	---
Manganese	Ton[d]	20,143	---	20,143	1,438	18,705	W	W	W	W	W
Zinc	Ton[c]	50,630	12,805	63,435	6,614	44,015	6.1[e]	26.1[e]	5.2[e]	47.2[e]	7.6[e]
Metals Average		57,600	46,881	104,480	14,296	43,301	6.2	8.7	3.3	27.3	9.2
Nonmetals:											
Construction materials											
Cement[a]	Bbl	57	---	100	40	17	60.8	80.1	34.2	86.0	204.4
Sand & gravel[f]	Ton[g]	255	9	264	25	230	4.8	116.5	3.1	40.4	4.6
Chemical & other materials	Ton[g]	860	2,862	3,724	555	305	6.6	1.4	1.2	10.1	18.2
Nonmetals Average		---	---	---	---	---	8.2	5.3	3.3	23.4	14.9

NA Not applicable. W Figure withheld to avoid disclosing individual company data.

[a] Production and water-requirement data based on plant capacities.

[b] Primary aluminum.

[c] Recoverable content of ores

[d] Manganiferous (5 percent of more Mn) or manganese (35 percent or more Mn) ore or concentrate.

[e] Includes lead.

[f] 1962 water-use and production data.

[g] Tonnage requiring water for processing.

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries,* U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D.C., 1966.

special plant wells. In the concentrator, water is recirculated at a rate of 2,000 gallons per minute, so that more than two-thirds of the plant's total water requirements come from recirculated water. Evaporation from the concentrator system totals 570 gallons per minute including two gallons per minute in the ore drying operation, three gallons per minute from the ore thickeners (where again there is a deliberate reduction in the water content of the ore), and over 560 gallons per minute from the tailings pond. This tailings pond covers approximately 130 acres. An additional relatively minor amount of water (in fact, only two gallons per minute) is lost as moisture incorporated in the final concentrate. Seepage from the tailings pond which returns to the environment as liquid is at a rate of 320 gallons per minute.[27]

It should be pointed out that water lost to evaporation is not really lost as far as the total environment is concerned but simply changes form and enters the immediate atmospheric environment rather than the ground or surface water environment. Of course, in the process of the evaporation-rainfall cycle it eventually returns to the surface water or groundwater environment, but usually at another place.

Throughout the copper industry the beneficiation process is the major user of water, with leaching operations being second. In general, froth flotation operations now use three times as much water as all leaching processes and more than 10 times as much water as mining operations. Smelting and refining processes are relatively minor users of water, normally using it only for cooling and cleaning purposes. In the United States in 1954, copper mining and beneficiation activities used more than 82 billion gallons of water. Of this, more than 63 billion gallons were used in the West, mostly in Arizona, Montana, Utah, and Nevada. Of this total, mines with adjacent beneficiating plants and beneficiating plants alone used almost the entire amount. Of the total of more than 63 billion gallons used in the West, however, only two billion gallons were actually consumed in the copper production process. The remainder were recirculated or discharged to the environment. Less than 30 percent of the water used in copper production in the West in 1954 came from company groundwater systems, while almost 45 percent came from combined public water and company surface water systems. Only one percent came from company owned surface water systems and virtually all of this was in Arizona. Public water systems supplied another 10 percent of the copper industry's water requirements in 1954.

2. Variations in Water Use by the Mineral Industries

The use of water by the mineral industries of the United States has varied from one region of the country to another and, within the Western states, from one state to another. In 1963, according to the United States Census of Mineral Industries for that year, there were almost 2,000 mining operations reporting significant water use in the Mountain States. Of these, more than 130 (6.5 percent) had an annual use of 100 million gallons or more. Almost 1,600 operations (80 percent), however, used less than one million gallons. For the United States as a whole, nearly 15,000 (80 percent) of the almost 19,000 establishments reporting water use for mineral purposes used less than one million gallons while more than 1,200 (6.5 percent) used over 100 million gallons. In the Pacific Coast Region reported water usage was less. There, of almost 1,300 establishments reporting water use for mineral processing purposes, 100 (7.1 percent) used 100 million gallons or more in 1963, while more than 950 (68 percent) used less than one million gallons.

In the Mountain States the greatest water usage has been in New Mexico. In 1963 almost 820 mineral operations in the state reported water use. Of these, 485 (60 percent) used less than one million gallons, while about 40 (5 percent) used more than 100 million gallons. In relatively arid Nevada, approximately 12 percent of the state's mineral producing operations used 100 million gallons or more of water in 1963. In rain drenched Washington, on the other hand, the total of such large water consumers was less than seven percent of all mineral establishments reporting water use. In Oregon, however, with a humid climate similar to that of Washington, such large water users accounted for only about three percent of all minerals operations reporting water use. In other arid parts of the West even higher

Table 13

WATER REQUIRED AND CONSUMED IN PRODUCING COPPER IN ARIZONA, 1960[a]

	Total intake		Consumption	
	Gallons per pound of copper	Percent	Gallons per pound of copper	Percent
Mining	1.1[b]	1.9	1.0[b]	11.1
Flotation concentrating	56.0[c]	96.2	7.5[c]	83.3
Smelting	1.1[d]	1.9	.5[d]	5.6
Total	58.2	100.0	9.0	100.0
Leaching	29.7	96.4	15.1	96.8
Smelting	1.1[d]	3.6	.5[d]	3.2
Total	30.8	100.0	15.6	100.0

[a] Excludes water required for powerplants and for domestic and miscellaneous purposes.

[b] Based on average grade of ore mined.

[c] Based on average grade of feed at concentrators.

[d] Based on Smelter output.

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries*, U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D.C., 1966.

percentages were obtained than in Nevada. In Arizona, approximately 15 percent of all minerals producing establishments used 100 million gallons or more of water, while less than 80 percent used under one million gallons.[28]

Apparently, the more arid the climate the greater the water use in the production of mineral commodities, although climate does not appear to be the critical cause in determining water use for minerals production. Water use in the mineral industries has varied much more according to the type of commodity being produced. Of the approximately 19,000 mineral producing establishments reporting water use in 1963, less than 15,000 used under one million gallons while more than 1,200 used 100 million gallons or more. Of the nearly 700 reported establishments in metal mining, a little more than 150 (21 percent) used as much as 100 million gallons or more. Of the various types of metal mining, the greatest water use occurred in the production of iron ore. More than one-third of the nation's iron mining operations reporting water use in 1963 used 100 million gallons or more. There were 56 such operations, compared to 60 operations that used less than one million gallons. In the processing of copper ores, about the same percentage of operations used 100 million gallons or more, but nearly half used less than one million gallons. Those operations producing lead and zinc ores had a similar pattern of water use. Of 89 total lead and zinc properties reporting water use, less than 30 used 100 million gallons or more in 1963 while 42 used less than one million gallons.

The production of gold and silver ores normally requires less water than the production of base metal ores. Of a sample of 74 establishments producing gold and silver ores in the United States in 1963, only 11 (15 percent) used 100 million gallons of water or more, while 54 (almost 75 percent) used less than one million gallons. Among the miscellaneous metals (including mercury, titanium, uranium, vanadium and metallic ores not otherwise classified, excepting tungsten, manganese, or bauxite). Of approximately 180 total reporting operations only 22 (12 percent) used 100 million gallons of water or more while nearly 135 (75 percent) used less than one million gallons. A similar pattern of water usage was found in the production of uranium and vanadium ores. Of a total of nearly 160 such operations,

Table 14

WATER USE BY METAL AND NONMETAL MINING INDUSTRIES, 1954 AND 1958, AND ESTIMATES FOR 1980 AND 2000 BY RIVER BASINS

[In millions of gallons]

	Water use, 1954[a]			Water use, 1958			Water use, 1980			Water use, 2000		
	Metals	Non-metals	Total	Metals	Non-metals	Total	Metals	Non-metals	Total	Metals	Non-metals	Total
1. Colorado River	19,272	1,066	20,338	16,347	1,571	17,918	23,316	2,306	25,622	18,075	1,788	19,863
2. Great Basin region	25,091	814	25,905	10,572	1,139	11,711	13,941	1,549	15,490	12,834	1,426	14,260
3. Missouri River, upper	2,873	18,783	21,656	3,785	7,693	11,478	7,219	14,656	21,875	6,247	12,683	18,930
4. Pacific region, northwest	12,500	NA	12,500	13,300	2,221	15,521	14,622	2,380	17,002	19,648	3,198	22,846
5. Pacific region, central	NA	9,599	9,599	4,486	15,419	19,905	9,213	30,845	40,058	19,664	65,831	85,495
6. Pacific region, south	119	9,617	9,736	12	6,554	6,566	---	15,992	15,992	---	33,673	33,673
7. Rio Grande and Pecos River, upper	2,429	5,320	7,749	2,546	2,433	4,979	3,800	3,650	7,450	5,467	5,253	10,720
Total	62,284	45,139	107,483	51,048	37,030	88,078	72,111	71,378	143,489	81,935	123,852	205,787

[a] Adapted from 1954 Census of Mineral Industries.

Sources of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries,* U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D.C., 1966.

Table 15

SOURCE OF WATER USED BY THE MINING INDUSTRY BY RIVER BASINS IN 1958

[In millions of gallons]

River Basin	Colorado River	Great Basin Region	Missouri River, Upper	Pacific Region, Central	Pacific Region, North-west	Pacific Region, South	Rio Grande and Pecos River, upper
Stream							
Metals	1,138	1,574	3,038	3,792	11,220	—	66
Nonmetals	542	368	3,025	924	980	27	276
Lake							
Metals	743	15	737	—	2,054	—	292
Nonmetals	22	6	3,533	22	1	1	2,025
Ground							
Metals	14,464	8,977	—	113	11	12	2,188
Nonmetals	982	556	952	3,132	1,098	5,223	132
Ocean							
Metals	—	—	—	555	—	—	—
Nonmetals	—	—	—	9,277	102	711	—
Other							
Metals	2	6	10	26	15	—	—
Nonmetals	25	209	183	2,064	40	592	—
Total							
Metals	16,347	10,572	3,785	4,486	13,300	12	2,546
Nonmetals	1,571	1,139	7,693	15,419	2,221	6,554	2,433
Totals	17,918	11,711	11,478	19,905	15,521	6,566	4,979

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries*, U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D.C., 1966.

approximately 120 (75 percent) used less than one million gallons, but less than 10 percent used more than 100 million gallons.[29]

Although the nature of the product has been an important factor in water use, size of operation seems more important. In keeping with the small firm characteristics of the industrial minerals industry, in 1963 there were a great number of such firms using relatively small amounts of water. Of the approximately 4,300 nonmetallic minerals producing operations reporting water use in 1963, almost 3,000 (68 percent) used less than one million gallons while only about 520 (12 percent) used 100 million gallons or more. Of these large water users, almost half (i.e., nearly 260) were sand and gravel operations. Less than half of the total, however (i.e., only 1,920), were sand and gravel operations. The production of chemical and fertilizer minerals generally required even greater water use than the processing of sand and gravel. Of the sample of 160 operations producing chemical and fertilizer minerals in 1963, almost 70 operations (44 percent) used 100 million gallons of water or more, while less than 60 (37 percent) used less than one million gallons. Of these, the greatest use of water came in the production of phosphate rock, potash, sodium and borate minerals. Of the approximately 75 reporting mineral operations so classified, 40 (53 percent) had a water intake of 100 million gallons or more while only 20 (27 percent) used less than one million gallons. Most other industrial minerals operations used relatively small amounts of water.[30]

3. Water Use in Metals Production

The use of water in the production of nonfuel minerals is much more closely related to the commodity being produced, the process being used, and the size of operations, than to geographical variables. Of these, the scale of production is undoubtedly most closely related to volume of water use. At the copper production complex of the Anaconda Company at Anaconda and Butte, Montana, for example, the water supply system operated by the company and used to furnish water to mineral processing facilities located at both Butte and Anaconda is a rather extensive system involving the collection, storage, transportation, treatment, pumping and repumping of water obtained from springs, wells, streams, lakes, and underground mines.

One of the principal sources of water for the Anaconda-Butte operations is a lake located 44 miles from the copper mining and beneficiation operations at Butte. It covers nearly 3,000 acres and drains an area of 53 square miles. When full, this lake has a capacity of more than 35,000 acre feet of water above the pump intake. During a third of the year, water is removed from the lake by three pumps (each with a 9,000 gallons per minute capacity) which lift the water into a wooden flume from which it is allowed to flow by gravity to another nearby lake. This much smaller lake is in effect the main storage vessel for water for the mineral producing operations at Butte and Anaconda. It has a surface area of 322 acres and drains an area of 111 square miles. When full, this lake stores more than 13,000 acre-feet of water above pump intake.

This smaller lake also feeds a creek from which additional water is taken closer to the city of Anaconda. About 10 miles downstream from the smaller lake, water is removed from this stream at a diversion dam. From there it passes through settling ponds and a series of screens to remove debris. The water is then treated with chlorine and ammonia. From there it is pumped through an eight mile long wood stave pipe to head tanks at the metal reduction works in Anaconda.

In addition to this lake and stream water, three miles further along the stream valley, three wells deliver about two million gallons per day to the city of Anaconda. These wells also provide a supplemental source of water for the advanced mineral processing operations there. Water is delivered from the wells to the city and the reduction works through a 3,000 foot long steel pipe line.

At the reduction works in Anaconda, the copper smelter, an arsenic recovery unit, a sulfuric acid plant, and a manganese kiln require water primarily for cooling purposes. The manganese and zinc differential flotation concentrators also require water for processing

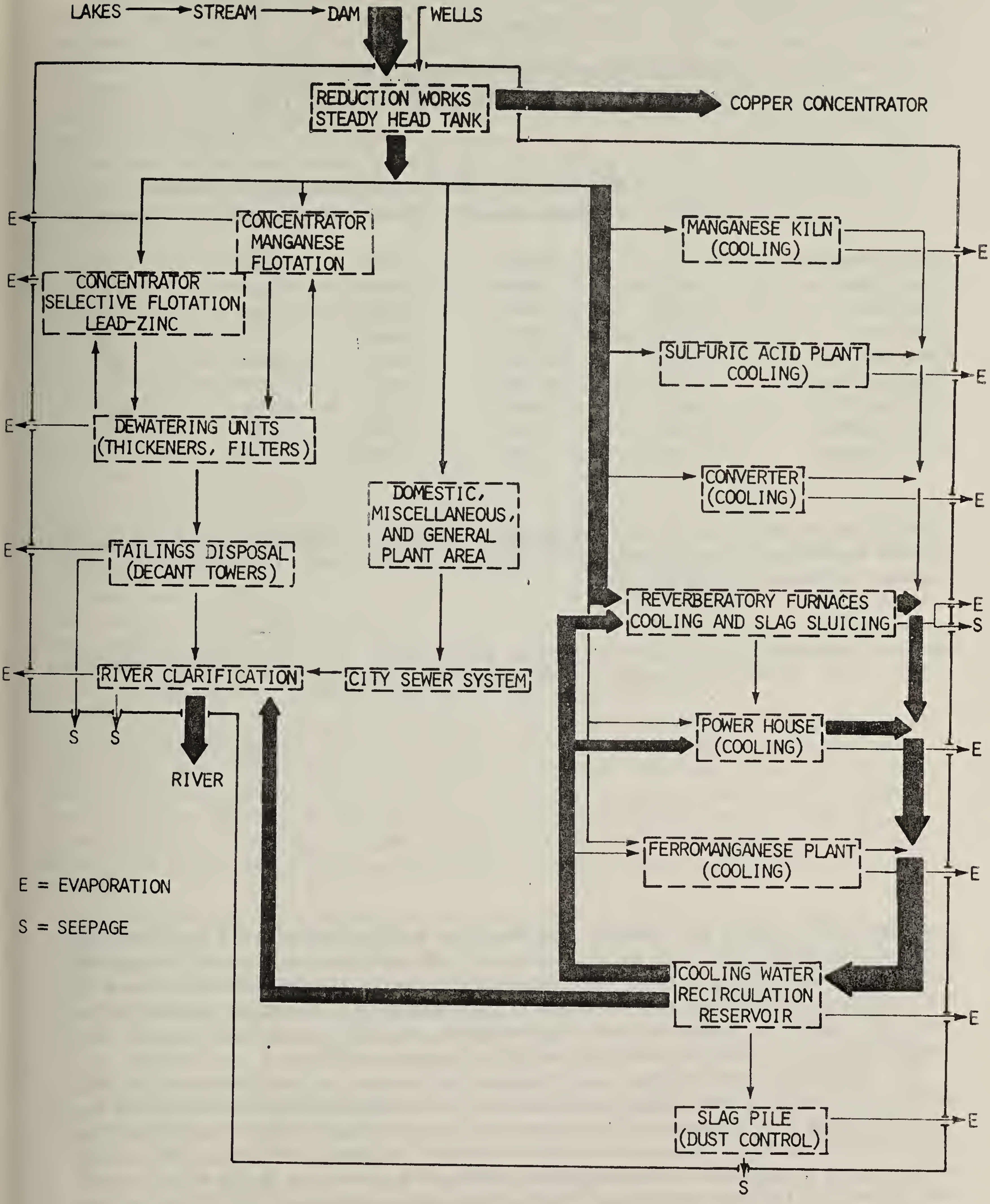

LAKES
STREAM
DAM
WELLS
REDUCTION WORKS STEADY HEAD TANK
COPPER CONCENTRATOR
CONCENTRATOR MANGANESE FLOTATION
CONCENTRATOR SELECTIVE FLOTATION LEAD-ZINC
DEWATERING UNITS (THICKENERS, FILTERS)
TAILINGS DISPOSAL (DECANT TOWERS)
RIVER CLARIFICATION
CITY SEWER SYSTEM
DOMESTIC, MISCELLANEOUS, AND GENERAL PLANT AREA
RIVER
MANGANESE KILN (COOLING)
SULFURIC ACID PLANT COOLING)
CONVERTER (COOLING)
REVERBERATORY FURNACES COOLING AND SLAG SLUICING
POWER HOUSE (COOLING)
FERROMANGANESE PLANT (COOLING)
COOLING WATER RECIRCULATION RESERVOIR
SLAG PILE (DUST CONTROL)
E
S
E = EVAPORATION
S = SEEPAGE

Fig. 88 - Schematic representation of the flow of water at the reduction works of the Anaconda Company at Anaconda, Montana. Substantial amounts of water are recirculated through various parts of the system. Total intake of new water is 27,500 gallons per minute.

Table 16

WATER USE PER TON OF CRUDE MATERIAL HANDLED, BY SELECTED COMMODITIES, 1962

	Gallons of Water Per Ton of Crude Material Handled				
	New	Recirculated[a]	Total	Discharged	Consumed
Bituminous Coal	102	445	547	84	18
Copper Ores	485	560	1,045	304	181
Gold Ores	1,213	92	1,305	1,198	15
Iron Ores	717	889	1,606	673	44
Phosphate Rock	1,831	4,208	6,039	1,362	469
Potash, Soda, Borate	293	1,422	1,715	177	116
Salt	3,617	1,101	4,718	2,752	865
Sand & Gravel	325	183	508	308	17
Stone, Crushed	83	26	109	77	6

[a] The quantity of water recirculated was primarily a function of availability, and dependent on process requirements, on the manner in which the water is used, on cooling, and on the necessity of treating the mill effluent.

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries*, U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D.C., 1966.

purposes, and of course, the sulfuric acid plant also requires water for the creation of its product. The entire plant has a water intake of 27,500 gallons per minute, fed through the eight-mile long, five-foot diameter wood-stave pipeline to the 165,000 gallon head tank at the reduction works. From this head tank, 15,500 gallons per minute are diverted to the reduction works in Anaconda and the remainder (12,000 gallons per minute), are transferred on to the beneficiation plant and other operations at Butte.

At Anaconda, approximately 12,250 gallons per minute of new water and 11,400 gallons per minute of recirculated water are used for cooling kilns and furnaces and for granulating slag. The manganese kiln requires a total of 1,000 gallons per minute of cooling water, and the cooling of the copper convertor requires 500 gallons per minute. The cooling of the copper reverberatory furnaces and the sluicing and granulating of slag are the largest uses for water at the reduction works. These uses use a combined total of 12,300 gallons per minute of which 3,300 gallons per minute are new and 9,000 gallons per minute are recirculated from the cooling water reservoir. The sulfuric acid plant uses 2,100 gallons per minute.

About 200 gallons of water per minute are discharged from the operation by seepage through the slag pile to underlying rocks. Approximately 2,000 gallons per minute evaporate and are lost. Another 2,000 gallons per minute are transferred to the powerhouse for use there, and 8,100 gallons per minute go to the cooling water recirculating reservoir. Cooling water requirements in the powerhouse total 7,650 gallons per minute. These are satisfied by reusing 1,500 gallons per minute of water from the recirculation reservoir as well as by transferring 2,000 gallons per minute from the reverberatory furnace cooling system and adding new water at a rate of 4,150 gallons per minute. The cooling water requirements for the manganese plant total 2,100 gallons per minute, of which 900 gallons per minute come from the recirculation reservoir and 1,200 gallons per minute are added as new water.

Of the 23,650 gallons per minute total cooling water requirements of the reduction works, 2,125 gallons per minute are evaporated by the cooling units themselves and lost. About 200 gallons per minute are lost through seepage and 21,325 gallons per minute are recirculated. From the recirculated water reservoir approximately 16 gallons per minute are also lost through evaporation, so that 11,400 gallons per minute are actually recirculated while 400 gallons per minute are used for slag pile dust control. Of these it is estimated that 360 gallons per minute are lost through evaporation and 40 gallons per minute discharged to the environment by seepage through the slag pile. A remaining total of 9,510 gallons per minute of used water are discharged to the river clarification disposal area.

There are other uses for water at the company's operations at Anaconda. In domestic and general plant area uses, about 250 gallons per minute are used and discharged through the city's sewer system to the disposal area. The company's zinc concentrator uses 1,600 gallons per minute of new water and 2,100 gallons per minute of recirculated water obtained from thickeners. The water requirements of the manganese concentrator and scrubber total 2,400 gallons per minute of which 1,000 gallons per minute are recirculated water while 1,400 gallons per minute are new water. The evaporative loss from both the concentrators and scrubbers is estimated at 66 gallons per minute. Part of this is lost in the thickeners and part is lost through direct evaporation in the concentration process and through incorporation as entrained moisture in the concentrate product.

The total water balance for the reduction works at Anaconda involves an intake of 15,500 gallons per minute. Of this, almost one-third (4,945 gallons) is discharged to the atmospheric environment through evaporation. Another 625 gallons per minute (four percent) are discharged to the groundwater environment through seepage, and 9,930 gallons per minute (64 percent) are returned to the surface water environment by discharge to a flowing stream. A total flow of approximately 40,500 gallons per minute is continually recirculated while 2,000 gallons per minute are transferred to uses outside of the immediate location.

Intake of new water is primarily from two lakes and a creek through a pipeline, with some additional water being supplied through wells. Discharge is through evaporation, seepage, and directly to a flowing stream *after clarification of the waste water* in a 400-acre clarification pond. A diagram of the water flow used at Anaconda is shown in Figure 88. The river clarification pond also receives approximately 250 gallons per minute from the city of Anaconda's sewer system, another 1,520 gallons per minute from the concentrator tailings disposal area, and 9,510 gallons per minute from the cooling water reservoir. The loss through evaporation from the clarification pond is estimated at about 1,100 gallons per minute while the loss through seepage from the pond is estimated at 250 gallons per minute. The remaining 9,930 gallons per minute are discharged directly into the head waters of the Clark Fork River.

The other principal water user of the Anaconda operations in Montana is the copper concentrator at Butte. This operation has a capacity for processing 42,000 tons per day of copper sulfide ore and was designed to require about 18,000 gallons per day of new water and 24,000 gallons per day of reclaimed water (i.e., 1,000 gallons of water per ton of ore processed). For the use of the concentrator, fresh water totaling 12,000 gallons per minute is obtained from the head tank at the Anaconda reduction works, being transported through

Table 17

WATER USE IN MINERAL INDUSTRY BY SELECTED COMMODITIES - 1962

	Water, million gallons per year					Gallons of New Water/Dollar Value of Product
	New	Recirculated	Total Used	Discharged	Consumed	
Anthracite	16,938	14,930	31,868	15,585	1,353	129
Barite	4,855	6,164	11,019	4,441	414	505
Clays	7,118	1,639	8,757	6,282	836	39
Copper Ores	81,035	93,590	174,625	50,707	30,328	99
Gold	54,566	4,155	58,721	53,921	645	158
Iron Ores	112,575	139,540	252,115	105,672	6,903	183
Lead & Zinc Ores	22,885	1,865	24,750	21,350	1,535	144
Lignite	18	18	36	8	10	181
Phosphate Rock	117,167	269,342	386,509	87,186	29,981	876
Potash, Soda & Borate	7,325	35,555	42,880	4,434	2,891	42
Sands & Gravel	217,601	122,732	340,333	206,236	11,365	283
Sulfur	17,604	161	17,765	12,956	4,648	169
Undistributed[a]	25,201	27,791	52,992	22,971	2,230	102
Uranium, Vanadium and Radium Ores	7,243	1,039	8,282	4,201	3,042	54

[a] Undistributed includes aluminum ores, ferroalloy ores, feldspar, flourspar, gypsum, magnesite and bollicite, manganese ores, mercury ores, mica, natural abrasives (except sand, pumice and pumicite), pyropnyllite, silver ores, soapstone, talc, titanium ores, tungsten ores, and miscellaneous nonmetals.

Source of data: Alvin Kaufman and Mildred Keller, *Water Use in the Mineral Industries,* U.S.B.M. I.C. 8285, U.S. Bureau of Mines, Washington, D.C., 1966.

a 23-mile-long, three-foot diameter pipe. The water flows by gravity for about two-thirds of this distance discharging into a sump between Butte and Anaconda. From the sump, three pumps force the water the remaining distance to the concentrator where a four million gallon concrete-lined, fresh water reservoir receives it. From the fresh water reservoir seven pumps lift almost 12,000 gallons per minute to a 50,000 gallon head tank with overflow going back to the reservoir.

The actual water requirements of the concentrator operation total almost 30,000 gallons per minute of which nearly 12,000 per minute are obtained from Anaconda. A relatively minor amount (75 gallons per minute) is transferred from the crushers at the mine and nearly 10,000 gallons per minute are recirculated from tailings thickeners. Another almost 8,000 gallons per minute are recirculated from the tailings disposal pond. Although all tailings from the concentrator are thickened (i.e., have their water content reduced) before going to the storage area, the tailing slimes go directly to large (100 yards in diameter) thickeners, while other tailings go through cyclones and smaller thickeners before going to the tailings storage area.

Most fresh water for the Butte concentrator is injected into the system by being added to the feed that goes into the tailing thickeners, near the end of the beneficiation process. The reason for this is to eliminate the bicarbonate ions found as harmful impurities in the intake water through the precipitation of calcium carbonate on the solid particles in the tailings before recirculation. This thereby forms as a means of chemical treatment of the intake water. The thickeners, with new water added, then overflow to a three million gallon reclaimed water reservoir. Of the 19,900 gallons per minute that go to the tailings pond, approximately 4,000 gallons per minute (20 percent) are lost through evaporation while 7,900 gallons per minute (40 percent) are retained as storage or seep into the ground. The remaining 8,000 gallons per minute are recirculated from the tailings dam to the concentrator's reclaiming water reservoir. The total reservoir storage capacity is more than 10 million gallons and this can provide water for about 30 hours of operation for the concentrator. From the reclaimed water reservoir, pumps take water to a 100,000 gallon head tank.

Total losses and evaporation in the concentrator system total a little more than 4,000 gallons per minute. Part of this loss is through evaporation in the thickeners, storage reservoirs and the tailings pond, while an additional amount is lost in the concentrator itself by direct process evaporation and by incorporation as entrained moisture in the copper concentrates.

Relatively small users of water at Butte are the mining operations. The City of Butte Water Department furnishes the Anaconda Company with approximately 2,200 gallons per minute of fresh water for cooling, dust control, drilling, and miscellaneous uses in both the open pit and underground mines at Butte. This amount and an additional 2,300 gallons per minute of mine water are centrally collected in a 4.5 million gallon sump located between two levels of one of the underground mines where there is a central pumping station.

Because much of the water that is collected from the underground mining operations in Butte Hill contains copper sulphate and other soluble copper minerals, it is pumped to the surface where it is sent to a central precipitation plant for the recovery of copper. All mine water is pumped or flows to a central pumping plant in one of the underground mines. Upon reaching the surface, approximately 5,500 gallons per minute of mine water are transported by open flume to the precipitating plant and surface leaching areas. Of the 5,500 gallons per minute pumped from the mines, about 200 gallons per minute are routed to the surface leaching areas, and the remainder go directly to the precipitation plant.

Of the total of 300 gallons per minute sent to the leach dumps, approximately 60 gallons per minute are lost through evaporation, while 40 gallons per minute seep into the underlying surface material. Approximately 200 gallons per minute (which contain more than a gram of copper per liter) are returned to a wooden flume for distribution to the precipitating plant. The total amount of water coming from the pumping plant and the surface leaching areas to the copper precipitation plant is about 5,500 gallons per minute.

The copper is precipitated from this water in wooden tanks by thin sheets of scrap iron or shredded tin cans. The scrap metal in the launders must be intermittently washed with a jet of water. This washing requires about 450 gallons per minute and is used to flush the precipitated copper into the settling tanks. From the launders, nearly 5,500 gallons per minute of water (with over 93 percent of the copper removed) are discharged into three colloidal settling tanks for the gathering of colloidal precipitated copper that is too light to settle in the launders.

The overflow of almost 5,500 gallons per minute from the final settling tanks of the precipitation plant is routed to a retention pond. A portion of the water from this pond is pumped either to the underground mines again (at a rate of 1,000 gallons per minute) or back to the surface leaching areas (at a rate of 100 gallons per minute) for further copper recovery. The balance of the water (about 4,400 gallons per minute) is discharged into the head waters of a nearby creek and is used there to treat the sewage produced by the city of Butte before final treatment 24 miles downstream in the river clarification area near the city of Anaconda.

In order to neutralize the moderately acidic water that is discharged from the precipitation plant, lime is added to the discharge creek through a lime feed ditch near the town of Anaconda. Although the treatment with lime makes the discharge water slightly alkaline, at the river clarification pond at Anaconda and before discharge into the Clark Fork River, the alkalinity is lowered to neutral. Water quality sampling stations located at several points along the surface water roots and chemical quality samples taken at these points are analyzed continually to maintain surface water quality.

Other copper producing operations in the Western United States have similar water using systems and requirements. At the operation of the Miami Copper Company Division of the Tennessee Corporation at Miami, Arizona, water is used extensively for in-place leaching of ground previously broken by a block caving operation. Leaching solution at Miami is distributed over the surface of the previously caved area to holes that have been drilled down through the leach material. In 1963 new water requirements for the leaching operation totalled 350 gallons per minute. Of this, 250 gallons per minute came from an inactive underground mine at nearby Globe, while 100 gallons per minute were obtained from groundwater supplies in the leaching area itself. This new water intake was required to replace approximately 350 gallons per minute lost through evaporation. Leach solvent at Miami is recycled at about 1,900 gallons per minute, essentially 2,000 gallons per minute minus the 100 gallons per minute of groundwater.[31]

The operation is in an arid area where water is scarce, but even if a large supply of low-cost, good-quality water were available, it is most likely that the 1,900 gallons per minute would still be recycled for other economic reasons, since this liquid contains a large amount of recoverable copper. The recycled leach solution also contains ferric sulphate which aids in the dissolving of the sulfide minerals in the copper leach material. Sulfuric acid, which also helps dissolve the copper oxide minerals in the ground, is also contained in the leach solution. Nevertheless, approximately 200 gallons per minute are discharged from the leach cycling system to a disposal pond, primarily to eliminate excess iron salts.

The new water obtained from the nearly underground mine is of good quality and two gallons per minute of this supply are used for domestic purposes at the Miami mine. About 69 gallons per minute go to domestic uses in the nearby town site owned by the company. An additional five gallons per minute for domestic uses are obtained from a nearby well. All domestic water is chlorinated.

In 1963, the new water from the underground mine at Globe cost approximately 19 cents per thousand gallons. This may be compared with a cost of $1.00 per thousand gallons paid by the Magma Copper Company for water of acceptable quality at nearby Superior, Arizona. In one instance (at Miami), the water is obtained from an old underground mine and is produced by the mining company itself. In the other instance (at Superior), the water is purchased from a private water company.[32]

The Miami Copper Company has another leaching operation in its Castle Dome unit about five miles west of its underground leaching operation. At Castle Dome the subject of

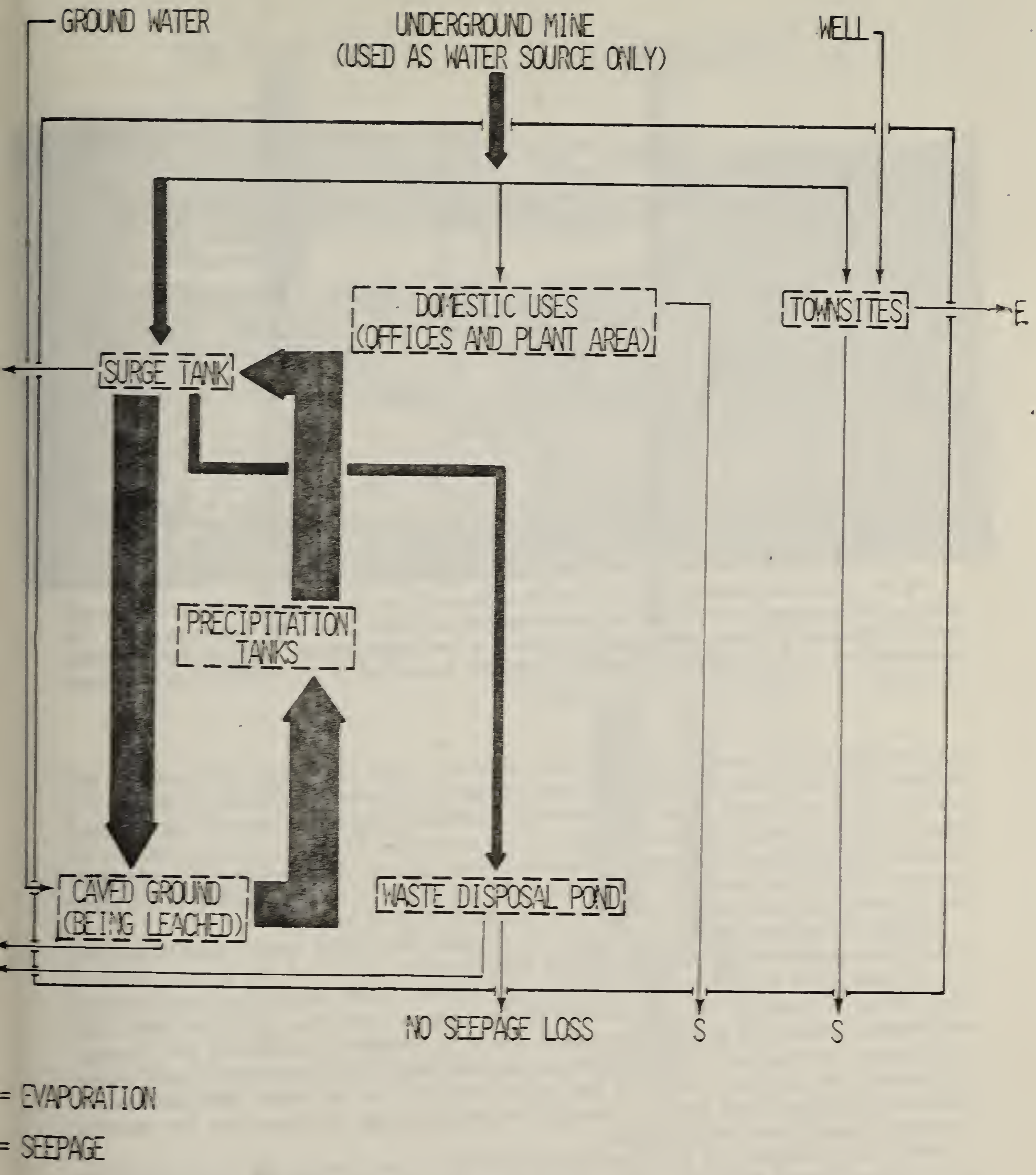


Fig. 89 - Schematic representation of the flow of water at the in-situ leaching operations of the Miami Copper Company at Miami, Arizona. Typical of leaching and other hydrometallurgical processes, large volumes of water are continuously recirculated through the system and new water requirements are relatively small. Total intake is only 426 gallons per minute.

Fig. 90 - The Castle Dome leaching operation of the Miami Copper Company in Central Arizona. At this operation, excess surface runoff is used in combination with well water to leach old mine waste dumps. The rate of production is directly governed by the supply of new water available. At most western mining operations the supply of water that must be developed is governed by the intended rate of minerals production.

the leaching is the waste dump left from a former open pit mining operation. At this property, run-off water is collected in two reservoirs. This source supplies 147 gallons per minute of the total leach water requirements. Another 60 gallons per minute are obtained from a 150 foot deep well, three miles from the operation. The total intake of new water, however, depends upon the amount available rather than the requirements of the leaching operation itself. The volume of production at Castle Dome in fact is adjusted to the water supply, rather than conversely as is the case at most mining operations.

Smaller mines have similar problems, but normally on a much smaller scale than either Anaconda or Miami. For example, at the Flux lead-zinc mine and the Trench flotation concentrator, both located southeast of Tucson, Arizona, water requirements are relatively small. Water for drilling and dust control in the mine is taken from the mine itself. This requirement totals two gallons per minute and it is considered completely lost through evaporation, although some water probably does seep back into the mine sump and is thus recirculated. No control is kept on this water, however. An additional eight gallons per minute are pumped from the mine simply for mine drainage purposes, and this water is discharged directly to a nearby stream.

New water requirements for the concentrator (which has a capacity of 100 tons per day of ore) are obtained from an inactive mine located approximately one mile from the mill site. The concentrator usage consists of about 14 gallons per minute of new water and 14 gallons per minute of recirculated water. A total of six gallons per minute are lost through evaporation from both the concentrator and the tailings pond, and eight gallons per minute

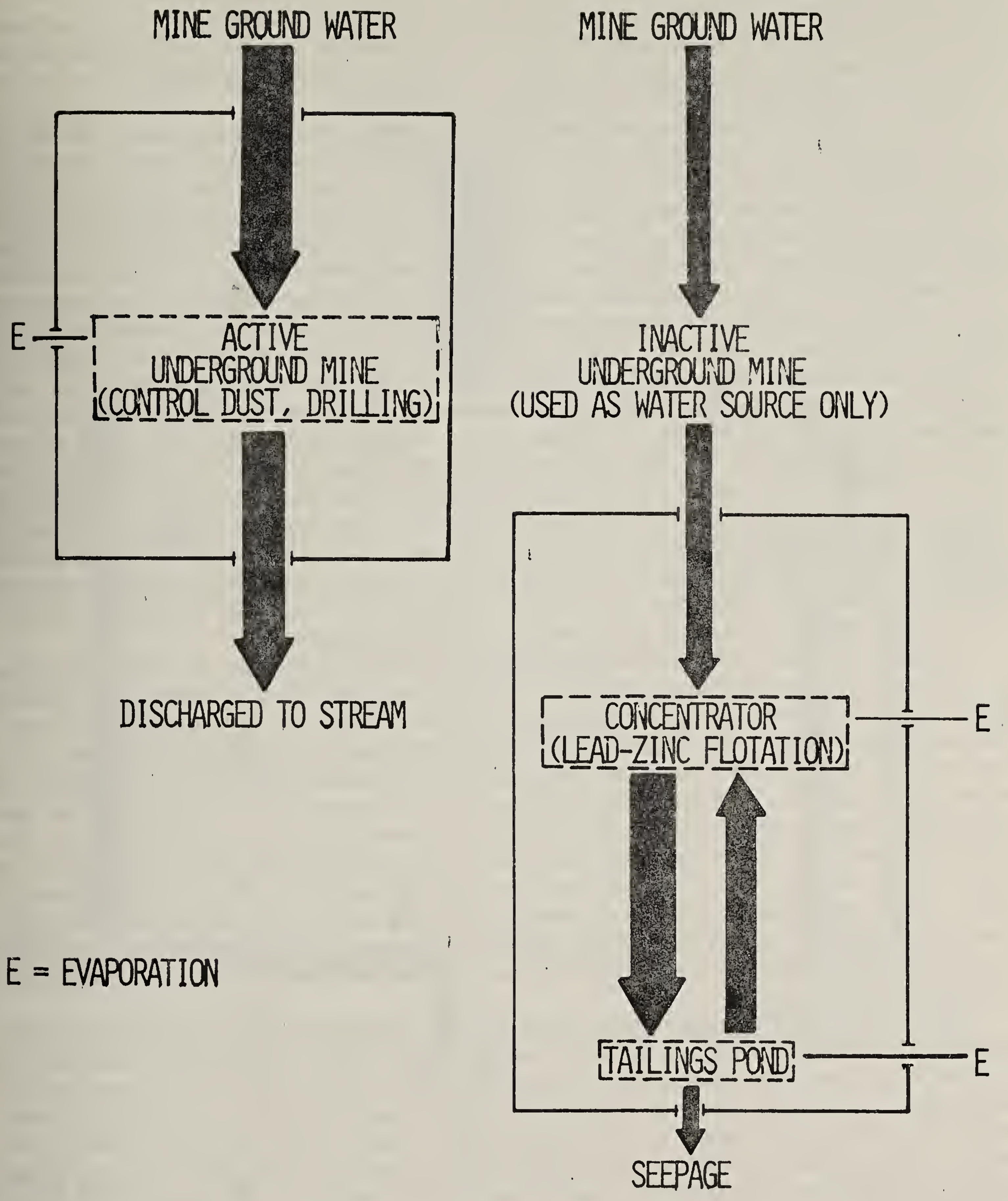

MINE GROUND WATER
MINE GROUND WATER
E
ACTIVE UNDERGROUND MINE (CONTROL DUST, DRILLING)
INACTIVE UNDERGROUND MINE (USED AS WATER SOURCE ONLY)
DISCHARGED TO STREAM
CONCENTRATOR (LEAD-ZINC FLOTATION)
E
E = EVAPORATION
TAILINGS POND
E
SEEPAGE

Fig. 91 - Schematic representation of the water flow in a typical small metallic mining and milling operation in the Southwest. The mine system depicted at left is completely independent of the beneficiation plant system at right which is located some distance from the mine. Where they are adjacent, mine water usually supplies all new water requirements for both. Total concentrator intake is only 14 gallons per minute.

are discharged to groundwater as seepage from the tailings pond. Domestic use in the five company-owned houses at the property and the changeroom amount to only 500 gallons per day, less than a third of a gallon per minute. The water balance of the system shown in Figure 91 involves about 24 gallons of water per minute of total intake, of which loss through evaporation amounts to eight gallons per minute, discharge to the groundwater environment through seepage takes another eight gallons per minute, and discharge to the surface water environment through a stream involves the remaining eight gallons per minute. A total of 14 gallons per minute are steadily recirculated.[33]

Water can be a problem, however, even for small mines, when it is particularly scarce. At the Orphan Mine (operated in 1963 by Western Gold and Uranium, Inc.), on the rim of the Grand Canyon, lack of water has been a particularly severe problem. Like most other uranium mines, however, the water requirements of the mining operation itself are relatively small. Because of the scarcity of water at the rim of the Grand Canyon, water was hauled for mine requirements from Williams, a town approximately 60 miles south of the mine. The underground mining operations required four gallons per minute of new water for drilling and dust control. The intermittent recirculation of drilling water averaged about one gallon per minute, while three gallons per minute were lost through evaporation and underground seepage. Domestic uses, primarily in company housing at the mine site, required an average of seven gallons per minute. Of this, four gallons per minute were discharged into the groundwater environment by seepage, while three gallons per minute were lost by evaporation. All new water was chlorinated before use, even that used in the mine for drilling purposes. The difficulty in obtaining water was reflected in its high cost, which was approximately $10 per thousand gallons. This was 10 times more than at Superior, Arizona, and 50 times as high as at Miami. The water balance for the system required a total intake of 11 gallons per minute, of which six gallons per minute were lost through evaporation, one gallon per minute was recirculated, and five gallons per minute were redischarged to the groundwater environment through seepage.

Uranium mines and mills in New Mexico have been far heavier users of water than those in Arizona. The mines themselves use relatively small amounts of water, however, compared to the processing plants. In fact, a number of wet mines, particularly in the Grants district, provide a ready supply of water for the processing plants in the immediate area. Near Grants, New Mexico, the Anaconda Company has a processing plant for the treatment of uranium ore using an acid leach method involving sulfuric acid. In 1963, the plant was processing about 1,450 tons per day of ore. To meet the water requirements of the operation, four wells in the immediate plant areas provided 665 gallons per minute of new water. The water content of the ore itself provided an additional 20 gallons per minute. Most of the water used in the acid leach process was pumped from two comparatively low-quality wells, to an elevated 100,000 gallon storage tank. The two other wells provided 130 gallons per minute of a higher-quality water which was used essentially for domestic purposes.

The intake for the processing plant itself totalled 554 gallons per minute of water. This included 500 gallons per minute from the storage tank, 20 gallons per minute contained as moisture in the ore itself, 14 gallons per minute transferred from the crushing plant, and an additional 20 gallons per minute of the higher-quality water obtained from the other two wells. Two gallons per minute of the higher-quality water were also used as feed for the boiler which supplied steam for drying the yellow cake output of the processing plant. About 15 gallons per minute of low-quality water were used in an unrecirculating cooling system for the compressors.

Waste water from the processing plant was discharged to a tailings pond covering 50 acres. The overflow of approximately 250 gallons per minute from this tailings pond was pumped to a disposal well, which was cased down through a portable water aquifer, thus permitting the discharge of waste water into a nonportable water aquifer at a depth of 1,400 feet. Domestic water requirements at the operation were comparatively large for the town site of approximately 100 company-owned homes. Water treatment was limited to domestic

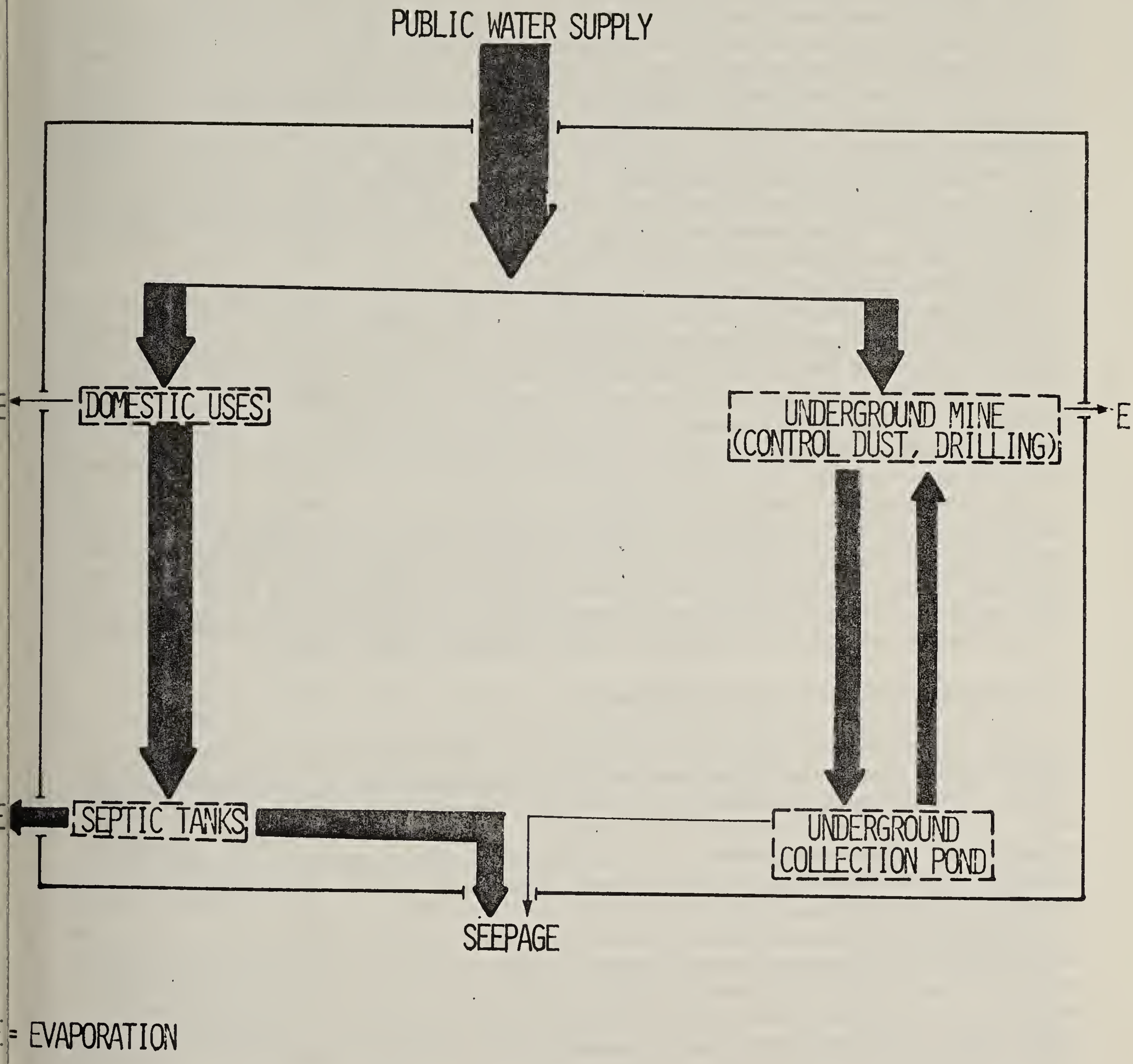

PUBLIC WATER SUPPLY
DOMESTIC USES
UNDERGROUND MINE (CONTROL DUST, DRILLING)
E
SEPTIC TANKS
UNDERGROUND COLLECTION POND
SEEPAGE
= EVAPORATION

Fig. 92 - Schematic representation of the water flow in a small uranium mine in the Southwest. An absence of groundwater makes the importation of high cost water from a distant municipality necessary. Most mines in the West, however, are able to generate enough water in excavation for their own uses and provide a surplus. Total water intake at this operation is 11 gallons per minute.

water with chlorine used to supress bacteria and a ployphosphate used to inhibit corrosion and scaling. The treatment cost for the domestic water was considered negligible. The cost of all new water for power, maintenance, and processing, as well as for domestic uses, was estimated at six cents per thousand gallons, certainly far less than the $10 per thousand gallons required at the Orphan Mine at Grand Canyon.

Another mill operated by the Homestake-Sapin Partners seven miles north of Grants, New Mexico, processed 2,500 tons per day of uranium ore using a carbonate leach method rather than the sulfuric leach process used by Anaconda. The primary source of water supply for this plant was from wells located in the immediate plant area. The two wells used supplied water at a rate of 325 gallons per minute, but water from one was of considerably better quality than from the other. The better-quality water was used about 85 percent of the time. The new water intake required by the Homestake-Sapin processing plant totalled 150 gallons per minute including 125 gallons per minute of direct make-up water and 25 gallons per minute contained as moisture in the incoming ore itself. In the process, however, the wet ore was partially dried to facilitate handling, and this required use of about 25 additional gallons per minute of new water for dust control purposes in the drying operation. Furthermore, the boilers supplying the steam for the closed circuit heating unit required another 35 gallons per minute of new water.

For tailings disposal purposes 100 gallons per minute of new water were added to the 1,015 gallons per minute of normal plant effluent. The tailings pond actually received a total of 1,180 gallons per minute, including an added 45 gallons per minute transferred from a septic tank at the plant. The 965 gallons per minute of water recycled from the tailings disposal pond to the processing plant were returned for metallurgical reasons rather than reasons of water economy, because of the high uranium and sodium ion content of the recirculated water. Recirculation was also used to prevent contamination of groundwater with these ions.

Evaporation losses from the tailings pond totalled about 215 gallons per minute including 100 gallons per minute of immediate evaporation and 115 gallons per minute through the eventual evaporation of moisture accumulated in the tailings. For domestic uses and miscellaneous nonprocessing requirements within the operation, the total amount of water used was about 20 gallons per minute. Of this, three gallons per minute were lost through evaporation and the remaining 17 were discharged to septic tanks.[34]

4. Water Use in Industrial Minerals Production

The production of nonmetallic minerals has also been a significant user of water in the Western United States. The one industrial mineral consistently requiring the greatest amount of water in its production is phosphate rock. Water use is heaviest in phosphate processing where refining for the extraction of elemental phosphorous is involved. Elemental phosphorous ignites spontaneously when brought into contact with air and therefore it is normally stored, handled, and shipped under a protective layer of water. Phosphorous is essentially insoluble in water.

At the Victor Chemical Works operated by the Stauffer Chemical Company in Montana, the elemental phosphorous plant is located on a centrally located 640 acre site and processes phosphate rock hauled from several company mines nearby. Water is used in the plant for washing, product storage, waste gas treatment, and cooling. The storage capacity of the sumps, tanks, and lines used to transport the elemental phosphorous itself approximates 1.4 million gallons.

Water requirements for the elemental phosphorous operation are obtained from three wells, each about 180 feet deep. Water from these wells is pumped to a 150,000 gallon storage tank used to maintain a steady pressure on the required flow of 655 gallons per minute of new water needed by the plant. Total plant requirements for the cooling of kilns, furnaces, and condensers, and for the storing of the elemental phosphorous product, amount to 1,800 gallons per minute. This total includes 300 gallons per minute of new water and 1,500 gallons per minute of recirculated water which are passed through a cooling tower. A boiler feed of 40 gallons per minute replaces a boiler loss of 15 gallons per minute plus the injected steam evaporation losses of 25 gallons per minute. The new water requirements of the powerhouse for cooling purposes amount to 300 gallons per minute. This water is not recirculated as such but is discharged to other plant uses. About 35 gallons per minute go to septic tanks and 40 gallons per minute go to a sump for subsequent distribution to the clarification system. The remaining 225 gallons per minute are discharged to the surface water environment through a nearby stream. Domestic water intake at the plant site totals about 15 gallons per minute which is eventually discharged to septic tanks.

A separate water system is maintained at the Victor Chemical Works for the washing of the phosphate rock. The water requirements for the washing operation are obtained from three wells where submersible pumps lift water to a 20,000 gallon head tank. From this tank 740 gallons of water per minute are distributed to the washing and gas scrubber operation to separate impurities from the run-of-mine phosphate rock, and also to treat discharge gases from the kilns in the elemental phosphorous operation. Total water requirements for washing total 800 gallons per minute. Of this, new water is added at 600 gallons per minute and 200 gallons per minute are recirculated from the dewatering units. The discharge from the dewatering units is pumped at a rate of 530 gallons per minute to a tailings pond.

One of the major uses of water in the entire operation is the treating of waste gases to prevent atmospheric pollution. Gases from the kilns used in the elemental phosphorous operation are passed through a waste gas collection system which removes fluorides. The water used in treating the waste gases is clarified and returned to the waste gas treatment system in a closed cycle to prevent water pollution as well as air pollution. A total of 1,540 gallons per minute are used in two scrubber towers to remove hydrogen fluoride from the waste gases. The new water intake for this operation totals 140 gallons per minute, while 1,400 gallons per minute are recirculated from the dewatering units. The discharge from the dewatering units is pumped at a rate of 110 gallons per minute to a tailings pond for discharge. This tailings pond, which covers 200 acres, thus receives 530 gallons per minute from the washing plant, 100 gallons per minute from the waste gas scrubbers, and 75 gallons per minute from the elemental phosphorous operation's slag pile. Water is lost from the pond through evaporation at a rate of 65 gallons per minute while 50 gallons per minute are allowed to discharge to the ground water environment through seepage into the underlying alluvium.

The three underground mine operations nearby, which supply the raw phosphate rock to the processing operation, use approximately 50 gallons per minute of water produced by the mines themselves. The 10 gallons per minute discharged from the mine changehouse are sent to septic tanks, while 40 gallons per minute are used in drilling and dust control in the mines. This water is eventually incorporated as entrained moisture in the phosphate rock output sent to the processing plant.

The total water balance for the processing plant, involving both washing and elemental phosphorous operations, includes 1,445 gallons per minute of water intake offset by 1,095 gallons per minute lost through evaporation, and 125 gallons per minute discharged to the ground water environment through seepage. Another 225 gallons per minute are discharged to the surface water environment through a nearby stream. A total of 3,550 gallons per minute are recirculated.[35]

The production of crude potash, unlike the production of phosphates, is a relatively light user of water in the Western United States. At the potash mining and processing operations of the United States Borax and Chemical Corporation near Carlsbad, New Mexico, for example, a 6,000 tons-per-day refinery processes material from a nearby underground mine. Water needs for the mine and plant are obtained from two wells in the immediate plant area. These wells, each about 350 feet deep, provide water for pumping to three storage tanks having a combined capacity of 100,000 gallons. The mine itself requires only two gallons of water per minute, all of which is used for dust control on haulageways. The total amount of water required for the processing system is 183 gallons per minute, of which 33 gallons per minute are used in tabling and flotation, and 150 gallons per minute

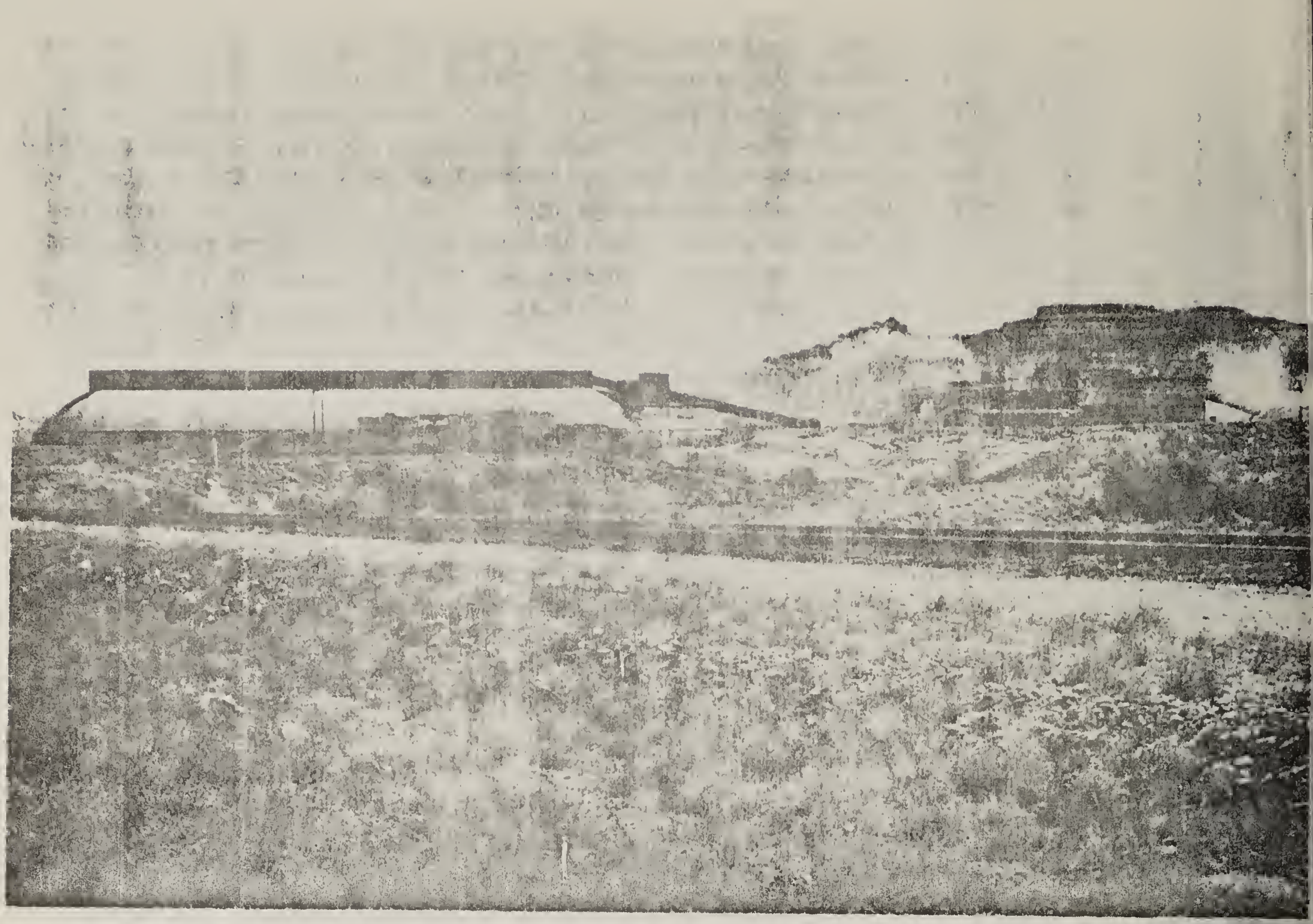


Fig. 93 - Potash mine and processing plant near Moab, Utah. The mining and beneficiation of potash, unlike the production of phosphates, is a relatively small user of new water in the Western United States, although the volume of recirculated water used in potash refining is extremely high. Water consumption at most western industrial minerals operations varies considerably.

are added to the plant discharge in order to facilitate the transportation of solid wastes to the salt dump.

Losses through evaporation consume the two gallons per minute used at the mine itself, as well as another four gallons per minute lost in product drying and through direct evaporation in the granular potash plant. An additional 15 gallons per minute are lost through evaporation at the salt dump and one gallon per minute is lost in the change room. From the waste dump, 164 gallons per minute are discharged to the groundwater environment through seepage.

Domestic water is purchased and hauled in by tank car for use in the plant's offices, shops, and laboratory. The total of this domestic water requirement, however, is less than two gallons per minute, and it is discharged to a septic tank along with the four gallons per minute discharged from the change room.

At the company's nearby potash refinery, which is a separate operation, new water requirements are obtained from the Pecos River and transported through a mile long canal at a rate of 3,000 gallons per minute. This water is used for the processing operation itself, in facilitating tailings removal, and in power generation. Approximately two-thirds of this new water supply is used to transport waste (mainly sodium chloride) to the natural lake disposal area.

In order to conserve water in this semi-arid region, the amount of new water added to the refinery discharge is controlled carefully. All tailings water is evaporated from the natural lake disposal area which is spring fed. Because of the artesian pressure under the lake, seepage from the lake is nil. Approximately five gallons per minute, however, are lost through evaporation in washing operations in the refinery and another four gallons per minute are lost by other direct evaporation, mostly in the drying of the refinery's end product.

Considerable water conservation is achieved by recirculation at the refinery. The total amount recirculated is 46,200 gallons per minute. Of this, 33,450 gallons per minute are used for cooling in the crystallization operation, and 12,760 gallons per minute are used for condensing steam in the power plant. A relatively minute 10 gallons per minute of condensate from the vacuum crystallizer are also returned to the boilers in the power plant for reuse. The new water requirements for the cooling tower include 800 gallons per minute of new water from the Pecos River as well as 86 gallons per minute of condensate transferred from the vacuum crystallizers.

Water for domestic uses at the refinery is purchased and kept in a 10,000 gallon storage tank. Domestic uses require about four gallons per minute of water of which three gallons per minute are discharged to the groundwater environment through seepage from a septic tank. The cost of the water used in the granular plant and for power is about 10 cents per 1,000 gallons. The water taken from the Pecos River for refinery uses costs less than one cent per 1,000 gallons. On the other hand, the average price of the water purchased for domestic uses at the mine plant is $2.14 per thousand gallons, delivered. Of this cost, 90 percent consists of railroad freight charges.[36]

Cement production in some places in the West involves extensive use of water, while in other places, the use of water by the industry is relatively negligible. The Trident, *dry-process* plant, operated by the Ideal Cement Company in Montana, has an annual output capacity of 1.5 million barrels of cement. Water at the Trident plant is used mostly for cooling purposes. The operation's water supply comes from three wells located at the plant site. Water from the wells is pumped to a 100,000 gallon storage tank from which water is distributed to the plant area at a rate of 145 gallons per minute. Of this total, 130 gallons per minute are used as cooling water for the kiln operations and also in crushing and grinding. Of this cooling water flow, 10 gallons per minute are lost through evaporation while 120 gallons per minute are discharged directly to the Missouri River. An additional 15 gallons of water per minute are used for domestic purposes in the plant area and at company housing units near the plant. This water is discharged to septic tanks from which it returns to the environment through evaporation and seepage. Water requirements for drilling and dust control in the company quarries are negligible.

South of Helena, Montana, the Kaiser Cement and Gypsum Corporation operates a *wet-process* cement plant which has a capacity of 1.6 million barrels annually, only slightly more than at Trident. At the Kaiser plant, water is also used for cooling purposes, but it is used more in making the slurry necessary in the wet process employed in the production of cement. Water requirements for the operation come from a well located at the plant site. From the 160 feet deep well, water is taken to a 360,000 gallon storage tank. New water flows to the plant at a rate of 271 gallons per minute, not quite twice the intake of new water at Trident. Of this total flow, 90 gallons per minute are used to replace losses through evaporation in the plant's boilers, and 156 gallons per minute are lost through evaporation in the kilns. Another 15 gallons per minute are lost through evaporation in the cooling operations, and about 10 gallons per minute are used for domestic requirements at the plant. The cooling water is recirculated to a cooling tank at a rate of 287 gallons per minute. A relatively negligible amount of water is used in drilling operations in the cement rock quarry adjacent to the plant.

The incoming water must be treated for both domestic purposes and for boiler feed. The water intended for domestic uses is chlorinated while the boiler feed water is softened by treatment with zeolites. No water is discharged directly from the system. Settling ponds are used to catch the unevaporated water from the boilers and from the cooling water reclamation tank and also to collect runoff surface water in the plant area. The only losses from the system are through evaporation. Of the total intake of new water at 271 gallons per minute, some water is lost through evaporation (at a rate of 261 gallons per minute) and some through seepage to groundwater (at a rate of 10 gallons per minute). There is no discharge to surface waters. Approximately 287 gallons per minute are recirculated within the system, while six gallons per minute are transferred from crushing operations to raw grinding operations and also could be considered as recirculated.[37]

Cement producing operations in New Mexico have similar variations in water requirements as do those in Montana. The Tijeras plant of the Ideal Cement Company near Albuquerque has an annual output capacity of 2.7 million barrels of cement, nearly twice the capacity at either Trident or Helena. New water requirements of the Tijeras operation are minimized, however, by the extensive reuse of water within the system. For example, in the quarry, dry dust collectors have eliminated the use of water in drilling operations. The total plant intake of new water amounts to 18 gallons per minute. This water is pumped from two deep wells located in the immediate plant area to a 200,000 gallon storage tank.

Domestic water requirements at the plant are almost nil, amounting to a total of one gallon per minute for the plant office area and residence. The remaining 17 gallons per minute of new water go to three cooling towers at the plant. The cooling tower for the mill building has an intake of 10 gallons per minute. This water is used to replace evaporative losses in the boiler and in the cooling of the ball mills, kilns, and air compressors. In these cooling operations 890 gallons per minute are recirculated. At the cooling tower for the feed building, 593 gallons per minute are recirculated and used in cooling the kilns and air compressors. This operation requires a new water intake of seven gallons per minute, of which approximately six gallons per minute are lost through evaporation in the cooling tower itself, while one gallon per minute is lost by evaporation in the waste storage area. New water requirements for the cement storage cooling tower are negligible, as this operation recirculates water at a rate of 30 gallons per minute.

Seepage losses from the entire system occur at the waste storage area and from septic tanks used for the domestic portion of the system. Of the total of 18 gallons per minute of new water intake, 16 gallons per minute are lost through evaporation, while two gallons per minute are lost through seepage. The entire plant uses a recirculated volume of water amounting to 1,513 gallons per minute.[38]

Sand and gravel operations in the West are normally heavy users of water, most of which is returned to the ground and surface water environment. Within the city limits of Reno, Nevada, the Isbell Construction Company maintained in the early 1960's a sand and gravel operation with both a pit and a washing plant. Industrial water for the plant requirements was obtained from a small pit in the plant area. A small amount of additional water for domestic uses at the plant was purchased from the Sierra Pacific Power Company. The plant required about 190 gallons per minute of new water to wash 1,200 tons of sand and gravel per day. There was no recirculation of the water used, and about 90 percent of the intake was discharged to a series of small ponds in the plant area. For washing operations, the quality of the raw intake water was adequate, and no prior treatment was necessary. The cost of producing the water from the pit itself amounted to approximately 26 cents per thousand gallons. The locally shallow water table permitted an ample supply of this water.

Of the total of 190 gallons per minute of new water intake approximately 23 gallons per minute were lost through evaporation, while 167 gallons per minute were redischarged through seepage. The settling ponds from which the seepage was discharged covered an area of about one acre. Evaporative losses from the settling ponds were estimated at about three gallons per minute, while evaporative losses in the washing the sand and gravel itself were estimated at about 20 gallons per day. Domestic use in the plant offices was considered negligible.[39]

Sand and gravel operations in Montana and the Pacific Coast states have also used extensive amounts of water. Many of these in fact are dredging operations taking sand and gravel directly from flowing streams or lakes. One dredging plant located at Missoula, Montana (in 1963) required about 405 gallons of new water intake per minute taken directly from the dredging sump. Of this total, five gallons per minute were used in the crushers, while 400 gallons per minute went to the sand and gravel washing plant which produced about 1,600 tons per day of finished sand and gravel. In this operation approximately 150 gallons per minute were lost through evaporation or as entrained moisture in the sand product. Another 255 gallons per minute were discharged to a dewatering unit where evaporative losses were nil. The excess water from the dewatering unit went to a 20 acre settling pond where evaporative losses amounted to 60 gallons per minute. Losses through seepage from the settling pond were estimated at 30 gallons per minute. The remaining 155 gallons per minute were discharged directly to the Bitterroot River.

In addition to the river itself, this operation also had a source of water in a 145 foot deep well which provided approximately five gallons per minute for domestic use in the immediate plant area. This water was lost through seepage. A second well provided approximately 10 gallons of water per minute for an associated ready-mix concrete plant producing 150 cubic yards per day. This water was largely lost through incorporation in the product itself, and there was no measurable seepage or evaporation loss from the ready-mix plant.

Of the total of 420 gallons per minute taken in by this combined operation, 210 gallons per minute were lost through evaporation, 35 gallons per minute were discharged to the groundwater environment through seepage, and 10 gallons per minute were incorporated into the concrete mix product. The remaining 165 gallons were discharged directly to the nearby river after dewatering for the removal of solids and after clarification in a settling pond. The only recirculation involved about five gallons per minute transferred from crusher operations to the sand and gravel washing plant mostly through entrainment in the product itself.[40]

A sample of 10 Arizona sand and gravel plants showed similar heavy water usage in 1960. For these plants, total new water requirements amounted to 3.9 million gallons per day (2,700 gallons per minute). Of this, almost half a million gallons (350 gallons per minute) were lost by evaporation or incorporation in the finished product, while 3.4 million gallons (2,350 gallons per minute) were returned to the groundwater environment through seepage. A total of about half a million gallons (350 gallons per minute) were recirculated within these plants.[41]

5. Liquid Waste Management in the Mineral Industry

In the 1800's the discharge of liquid wastes from mineral industry operations was not considered a particularly important problem. Water that was not lost through evaporation or seepage and not needed in the production process was discharged to the surface water environment, wherever convenient. Liquid waste disposal was in effect a problem only for adjacent minerals producers who had heavy water requirements of their own operations. As both placer mining operations and agricultural development in Central California grew, however, the discharge of siltladen effluent from dredging and sluicing operations did become a problem. The problems caused by suspended solids in discharge water has remained the most important concern in liquid waste management by the nonfuel mineral industries ever since.

Although it has been of considerable importance in coal mining operations, the creation of acidic liquid waste has never been a serious problem in the nonfuel mineral industries. Where it has been a problem, it has been limited primarily to mining operations involving sulfide minerals. Even the effluent from such operations, however, is normally not discharged to flowing streams. Since the advent of froth flotation methods in the early 1900's liquid waste discharge has been almost entirely through seepage from tailings ponds, which are settling and purifying devices.

Water pollution has been defined as the creation of water of unsuitable quality for use by others. In a good many mineral operations, however, the mining and beneficiation processes in effect are using water polluted by others and actually must improve the quality of their intake water, at least for their own purposes. For example, water required for froth flotation concentration operations in the lead, zinc, and copper industries must be kept at a definite acidic content and must be treated to remove harmful ions that would increase its alkalinity and its hardness prior to use. In many other instances, hard water must be treated to remove scale producing components before use in the industry's boilers or cooling systems.

The treatment of effluent from mineral producing operations had become normal practice throughout most of the nonfuel minerals industry. At the operations at Anaconda and Butte, Montana, previously described, in order to neutralize the acidic water discharged from the precipitation plant at Butte, lime is added to the nearby creek through a lime feed ditch. During the winter months when the creek is normally frozen over, discharge water is diverted through a canal and passed through the tailings storage area of the reduction works for treatment. A secondary reaction with the lime occurs at the reduction works tailings storage area before the water effluent reaches the river clarification pond. The quality of the water is thereby raised to a moderate alkalinity at the lime feed ditch and the secondary reaction raises it even further. In the river clarification pond, however, under further treatment, the alkalinity is lowered to neutral. Water quality control stations are located at four points and samples are taken continually at these points to maintain the harmless quality of the effluent.[42]

Water pollution is generally no problem for cement plants or for sand and gravel operations if normal procedures are followed. The procedures for controlling the quality of water effluent, however, do differ from one operation to another. In sand and gravel operations in live stream beds, one problem is the turbidity and sediment created downstream from the operating area. In areas of continuous flow such sediments may choke the oxygen level of the water and affect the fish habitat. Devices have been developed, however, to offset this. A machine using a high pressure jet and suction pump can remove sediment, leaving clean and porous gravel in a river bed. In some places, such as at the Clarksville, Missouri, plant of the Dundee Cement Company, an expensive treatment plant that returns water to the river cleaner than it takes it out has resulted in an expenditure of $554,000 for the treatment plant alone and an annual expenditure of $54,000 for treatment chemicals.[43]

Water pollution has also been defined as an impairment of water quality that is injurious to the stability of water for defined uses. Most of the pollution of water by the nonfuel mineral industry occurs in the form of sediment. In the West, chemical pollution is relatively negligible. Possible chemical pollution does present potential problems, however. Large quantities of water are essential to many mineral processing and beneficiation operations. Various chemicals are added to the water in the course of these operations to promote the separation of valuable minerals from gangue material. Eventually, both the soluble and insoluble waste is carried by water to a place where it must be stored or converted to a useful form by some chemical, biological, or physical means.

The treatment of mineral industry effluent typically incorporates some system of holding or storage ponds where settling is allowed to take place, and water is discharged to the environment almost entirely through seepage and evaporation. An essential characteristic of these storage ponds is that they are designed to minimize the possibility of dike failure and any subsequent uncontrolled discharge of materials in amounts that would be injurious to designated downstream uses. In many areas of the West, of course, there are no flowing streams but care must still be taken to avoid uncontrolled discharge to areas at lower elevations within the same watershed.

A significant contributor to water pollution in the Eastern United States is acid mine drainage, particularly from abandoned coal mines. Acid mine waters normally contain dissolved minerals which will precipitate upon the gravel and rocks of stream beds, often discoloring the bedrock, and creating a hardpan which is impermeable and frequently biologically sterile. Control methods used to prevent this adverse effect range from the sealing of old mines and diverting surface runoff to direct neutralization and precipitation of these minerals from mine waters before they reach a receiving stream. Surface drainage passing over or through unprotected mill tailings piles or mine waste dumps may also contribute harmful chemicals to flowing streams.[44]

The full ramifications of acid mine drainage as a pollutant of surface waters are not adequately understood at the present time. Considerable research is in progress, however,

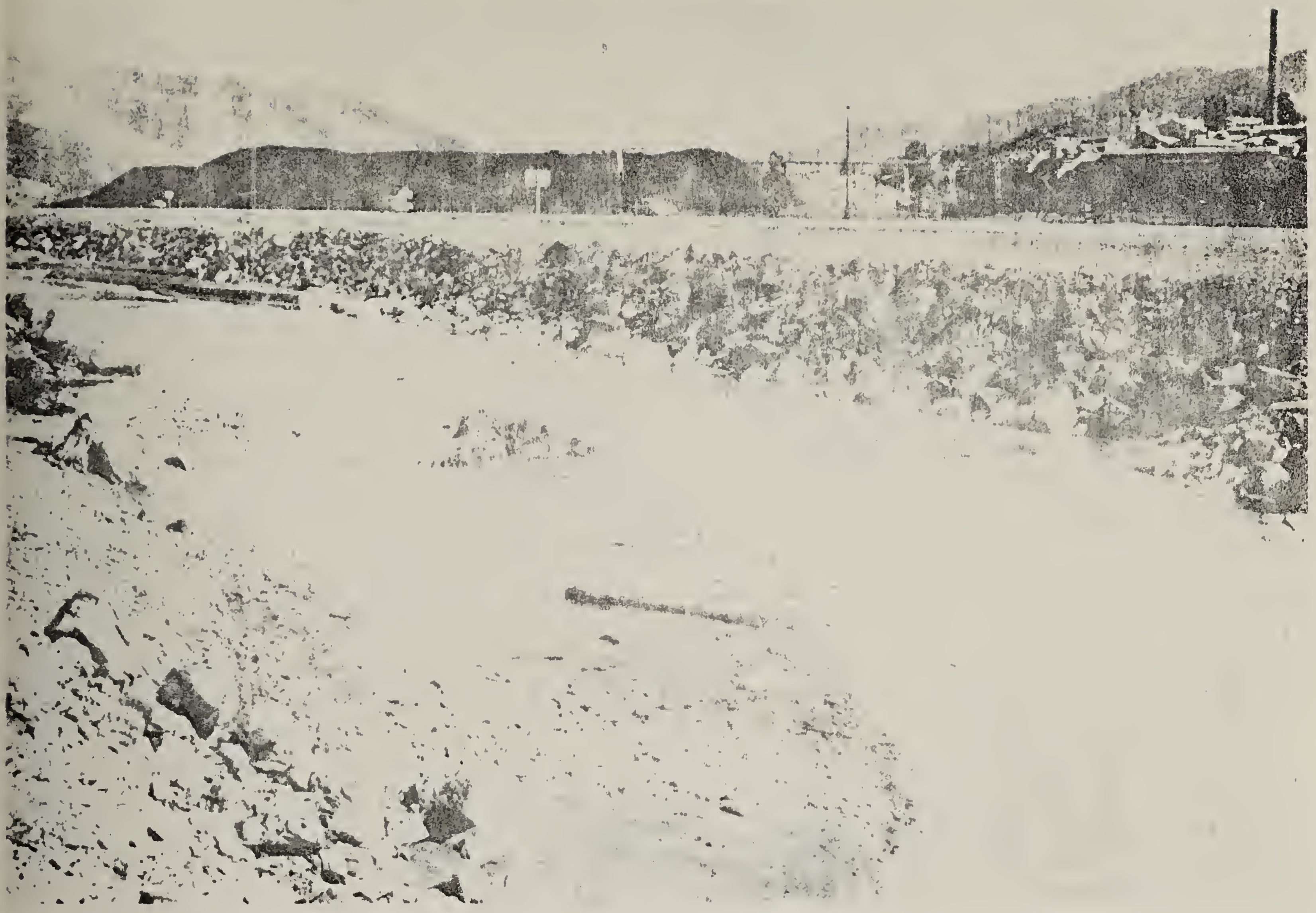


Fig. 94 - Water containing high concentrations of iron and solid matter contaminants in the Coeur d' Alene River near Kellogg, Idaho. The source of much of the solid contaminants appears to be the erosion (caused by the disturbance by construction operations) of fine mill tailings created by mining operations in the district.

mostly conducted by the industry itself. At the present time methods are available for the alleviation (at least in part) of the pollution of flowing streams by acid mine drainage. First, there are means to prevent the entrance of as much extraneous water into mines as is possible. This has always been a concern of the mineral industries. Second, the removal of water from a mine can be made as rapidly as practicable after it enters the mine, thus minimizing its contact with soluble minerals. This, in many respects, has also been a major goal of mining operators in the Western United States since the middle 1800's. In some operations, however, particularly those involving leaching and solution mining, just the opposite is the intent of mine operators. Where maximum exposure to soluble minerals is desired and promoted, however, minimum discharge of mineral bearing solutions is also desired.

Considerable research has been conducted to date by the mineral industry itself with regard to the treatment and disposal of liquid wastes. Deep well injection of liquid wastes has been investigated as a method of disposing of harmful mine effluents and in some cases, as in uranium processing, is being used. Research has also been conducted regarding controlled outflow into streams from points near mine water outlets and considerable work has been done in sealing abandoned mines above drainage outlets.[4 5]

The most vexing of the technological problems encountered in the adverse effects of mineral industry water use upon the physical environment, however, are not those concerned with water sources or the methods of treatment of industrial wastes. Rather they are concerned with the effects of waste constituents on receiving surface and subsurface waters and the capacities of those waters to assimilate certain constituents without adversely affecting other uses of the water. At the present time, it is really not known what effects phosphates, nitrates, and similar fertilizer nutrients found in some chemical wastes have on other resources. Similarly, the real tolerance of some flowing streams towards such toxic items as cyanide, chromium, copper, cadmium, and arsenic compounds that result from mineral processing operations is unknown. The effects of thermal pollution are virtually unknown, as are the specific results of increased turbidity. There is simply too great a lack of reliable data on the nature and quantity of industrial liquid waste discharges to arrive at generalizations. Even the complete effects of excess sedimentation are not entirely known.[46]

Through the years, the primary emphasis on reducing or eliminating the adverse effects of nonfuel mineral industry activity on water resources seems to have been on the treatment of waste water by one manner or another. In earlier years, because of the relative abundance of the nation's water resources not much attention was paid to the reuse or subsequent flow of the water supplied to the industry except in the arid regions of the Southwest and Great Basin. Nevertheless, the requirements of the mineral industry pertaining to water have increased steadily. This fact, combined with the realization that there is beginning to be a depletion of groundwater supplies, and that an increasing amount of the water available to the industry is of low quality, has necessitated extensive research into methods of reducing or eliminating such adverse effects of mineral industry water discharge. Such research has proved advantageous to the mineral industry especially since the demand for water throughout the nation was increased. An improvement in conventional water treatment practices and the development of economic methods of converting saline or brackish water offer strong possibilities for developing a more adequate supply of water for the mineral industries.

Liquid waste management and water quality problems have not been uniform throughout the nonfuel minerals industry. One of the most important problems encountered is the possible adverse effects of water discharge resulting from its radioactive content. The Colorado River Basin has received extensive study as a result of this potential for long range radioactivity pollution. Uranium mining does not contribute significantly to such pollution, but the processing of uranium ore results in the creation of both liquid and solid waste with a high proportion of radioactive material. Most of this radioactive waste is found in the tailings storage areas.[47]

As in base metal processing, hydrometallurgy is an important technique in the processing of uranium materials. This necessarily involves cyclic flow of aqueous solutions and acid consumption and control. Until the 1950's uranium processing waste was normally disposed of by dumping in streams. Sedimentation, acid pollution, and radioactivity were then prevalent in the nearby streams of uranium producing areas just as sediment was common in the early days of gold placer mining. After the initial years of production, however, impoundment facilities, chemical treatment plants, and the stockpiling of solid tailings became common practice. Improved dam construction reduced the hazard of tailings dam failures. Short term radio-chemical pollution has been controlled. Another technique developed for the effective disposal of uranium mill liquid wastes has been deep well injection. At present the use of this method is limited, but the possibility exists for similar operations in areas of porous sedimentary rock strata, usually sandstone, limestone, or dolomite that are permeable enough to readily accept large amounts of fluid wastes. Such a well must be capped above and below the groundwater table, however, and the solid content of the injected material must be extremely low.[48]

Water pollution from copper and other base metal producing operations is usually the result of accident rather than normal practice. During the copper strike of 1967-68, for example, Anaconda's copper mining and processing operations at Butte, Montana, were closed by the dispute. The acid solution pumped through the waste dumps was not precipitated afterwards as would normally be the case. The resulting high acid and high copper-bearing fluid wastes were dumped into the Clark Fork of the Columbia River. Although lime treatments were utilized even during the strike by supervisory personnel, they simply formed a light precipitate that would not settle out permanently. Although a court order was obtained to prevent the company from discharging water in this manner,

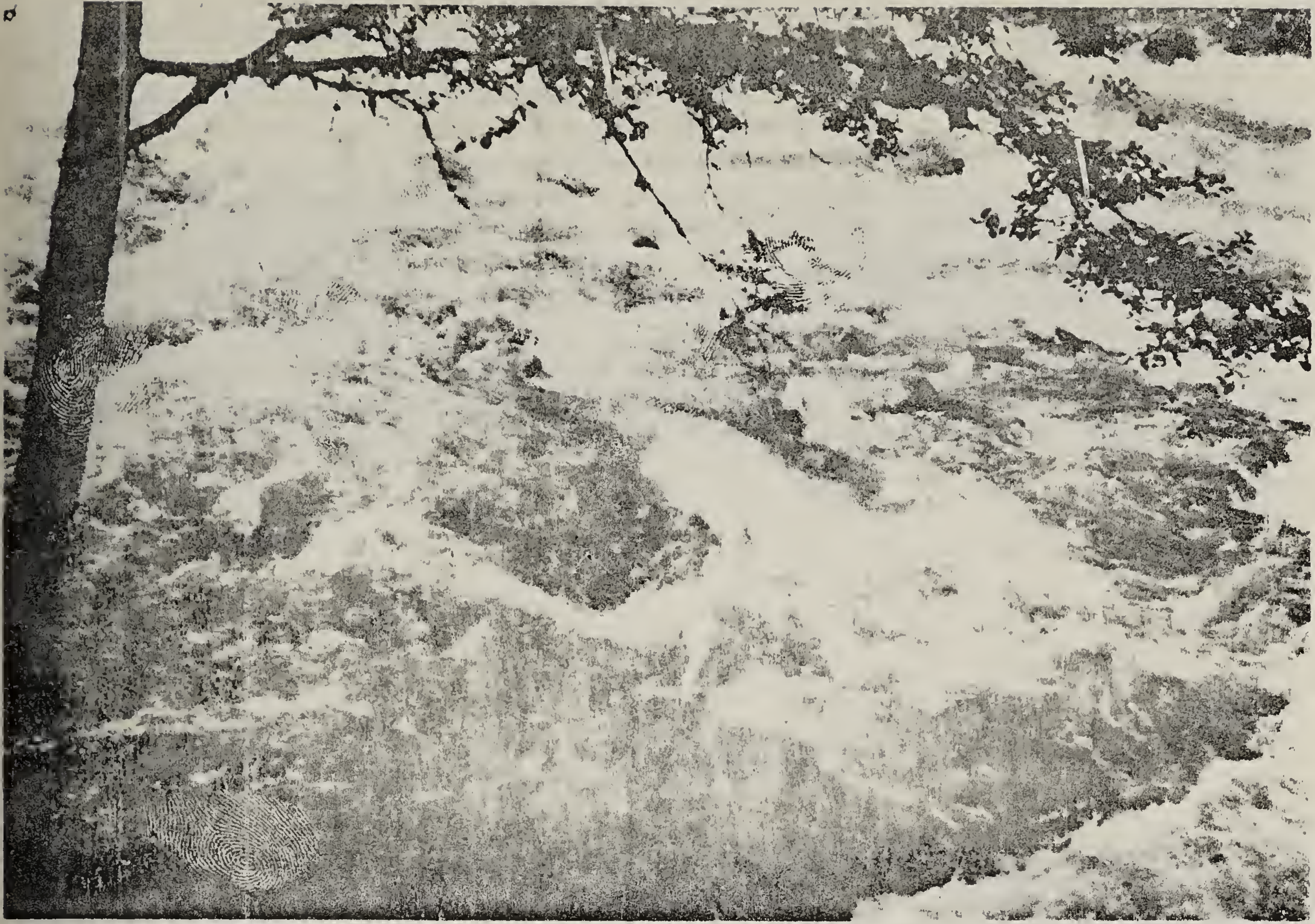


Fig. 95 - Turbidity caused by suspended solid matter in the North Fork of the Nooksack River near Glacier, Washington, within the boundaries of the Mt. Baker National Forest. Principal cause of the turbidity was heavy runoff and the resultant accelerated erosion after heavy rains. There are no mining operations in the immediate area.

the end of the strike and the resultant reopening of the copper precipitation plant halted the pollution.[49] Similar pollution events have occurred in other states.

In contrast to this are more normal practices regarding water use and discharge by the mineral industries. The Phelps Dodge Corporation in Arizona, for example, in cooperation with that state's Salt River Irrigation and Power Project and others, developed a broad network of dams, pumping plants, and pipelines in East-Central Arizona. The project involved the pumping of water into normally dry creekbeds in the scenic mountain country of Eastern Arizona. Fishing and recreational interests as well as an additional water supply were realized.[50] Both the Anaconda Company and the White Pine Copper Company in Michigan have initiated programs for the control of harmful effluents from their operations that have cost more than half a million dollars for Anaconda and six million dollars for White Pine. The program at White Pine involves both extensive tailings dams and a water pollution control system. These are typical of the practice of the nonfuel mineral industries on the public lands of the United States.

6. Summary

Throughout the West the supply of water available to the mineral industry has been, in most instances, favorably affected by water allocations based strictly on economic considerations, including both the value of the product and the personal income generated by the industry. In competition for water the mineral industries as a whole are generally able to pay a higher price than most other uses, certainly much more than agricultural users. On the other hand, the supply of suitable water available to the mineral industries has been adversely affected by any decrease in overall supply, particularly that which has resulted from dropping water tables and increases in demand by others, particularly urban users, including commercial as well as residential users.

Population increases throughout the West, with resultant expansions in the markets for industrial minerals, have created a greater demand for water by those industries. Many mineral industry operations would certainly use more new water if the cost of water were less. Demand for new water tends to be decreased, however, by technical changes in mineral processing, by improvements in water treatment methods permitting greater recirculation, and by improvements in the methods used to control evaporation. Techniques used in leaching operations to prevent seepage losses also have limited the demand for new water by the mineral industries. New processes involving the use of water, however, have tended to increase the demand for that commodity. It is most likely that the new water requirements of the mineral industries in the West will continue to increase. As water demand and costs rise, the tendency to discharge liquid wastes to the surface environment will decrease.

Fig. 96 - Water containing high concentrations of sulfur and iron contaminants entering the Sacramento River watershed from natural springs in Lassen Volcanic National Park in Northern California. Formerly worked on a small scale for surface deposits of sulfur, the area now has no mining operations, and is part of the National Park System.

Fig. 97 - The lake in the background of this view from The Arches National Monument near Moab, Utah, is a tailings pond adjacent to a uranium mill and processing plant alongside the Colorado River. Such tailings ponds are commonly used to settle harmful wastes from plant process water before returning the water to the environment, usually through seepage or evaporation.

B. MINERAL RESOURCES AND ATMOSPHERIC RESOURCES

1. Gaseous Waste Management in Mining

The control of gaseous waste products has long been a strong concern of the mineral industries. The concern arose originally in the mining phase of minerals production because of the particularly adverse effects created by the gaseous waste products created in underground mining operations and because of the resultant need for strict control of the quality of mine atmospheres. The mineral industry's first efforts at controlling the relationships between atmospheric resources and mineral production activity were thus aimed primarily at providing a healthier environment for the industry's own workers.

Mine atmospheres must also be controlled to meet certain legal requirements, imposed in some instances by states and in others by federal regulations. Controls have been imposed in the interest of human welfare, primarily to meet the needs of human comfort, health, and safety. In some mines, atmospheric control is also necessary to maintain a satisfactory degree of efficiency in the laboring force. Extremely hot mines require air conditioning or cooling if workmen are to maintain high productivity.

The specific reasons for air conditioning or ventilating mines are several. Most important, ventilation must be undertaken to maintain the oxygen content of the air at a safe level. The United States Bureau of Mines recommends that the minimum allowable concentration of oxygen in the exhaust air of a mine is to be 19.5 percent. Second, ventilation must be adequate to dilute and/or remove harmful gases so as to keep them below maximum allowable concentrations (see Table 18 for maximum allowable concentrations of harmful atmospheric contaminants encountered in mining operations). Harmful gases include poisonous or corrosive gases, suffocating gases, gases that form explosive mixtures in air, and radioactive gases. Atmospheric control must also be sufficient to remove and/or dilute harmful aerosols to below maximum acceptable concentrations. These aerosol contaminants are suspended liquid and/or solid particles such as dust, smoke, or vapors (see Table 19 for maximum allowable concentrations of dusts).

There are other specific reasons for controlling mine atmospheres. Air must flow through all active parts of a mine with sufficient velocity to maintain a safe, comfortable, and wholesome atmosphere. Involved in this is the control of the temperature and humidity of the air. This is done in some areas to prevent icing in shafts in cold weather. Hot mines, on the other hand, may require refrigeration or air cooling. Transformer stations and rectifier stations may require special cooling. Underground explosive magazines also require special attention to ventilation.

Appropriate ventilation is absolutely necessary to control or contain fires in mines. Fresh air is introduced into any underground mine at the shaft or tunnel where men enter and leave the mine, and the used air is exhausted elsewhere through another passage. In case of an underground fire, men must evacuate the mine usually along their customary route of egress or through a designated escapeway. When mine fires burn out of control, the only effective method of extinguishing them is to seal off completely the flow of fresh air to the mine for a period long enough to allow the workings to cool.

There are various measures of controlling atmospheric contaminants in mines.[51] The most effective involves *prevention.* This in turn entails the use of proper procedures in blasting, the proper adjustment and maintenance of internal combustion engines, and maximum avoidance of open flames and fires. The second major method of treating harmful atmospheric components is by *removal.* This involves the drainage of harmful gases (in advance of mining as well as during mining) and local exhaustion by forced ventilation. This, of course, does not eliminate the problem but transfers it to another environment. Harmful components are often eliminated, however, by *absorbtion.* Two of the major processes used in such treatment involve chemical reaction in internal combustion engine conditioners and solution by air-water sprays as used in blasting. Another method of elimination is through *isolation,* usually by sealing off abandoned workings or fire areas, or by restricted or off-shift

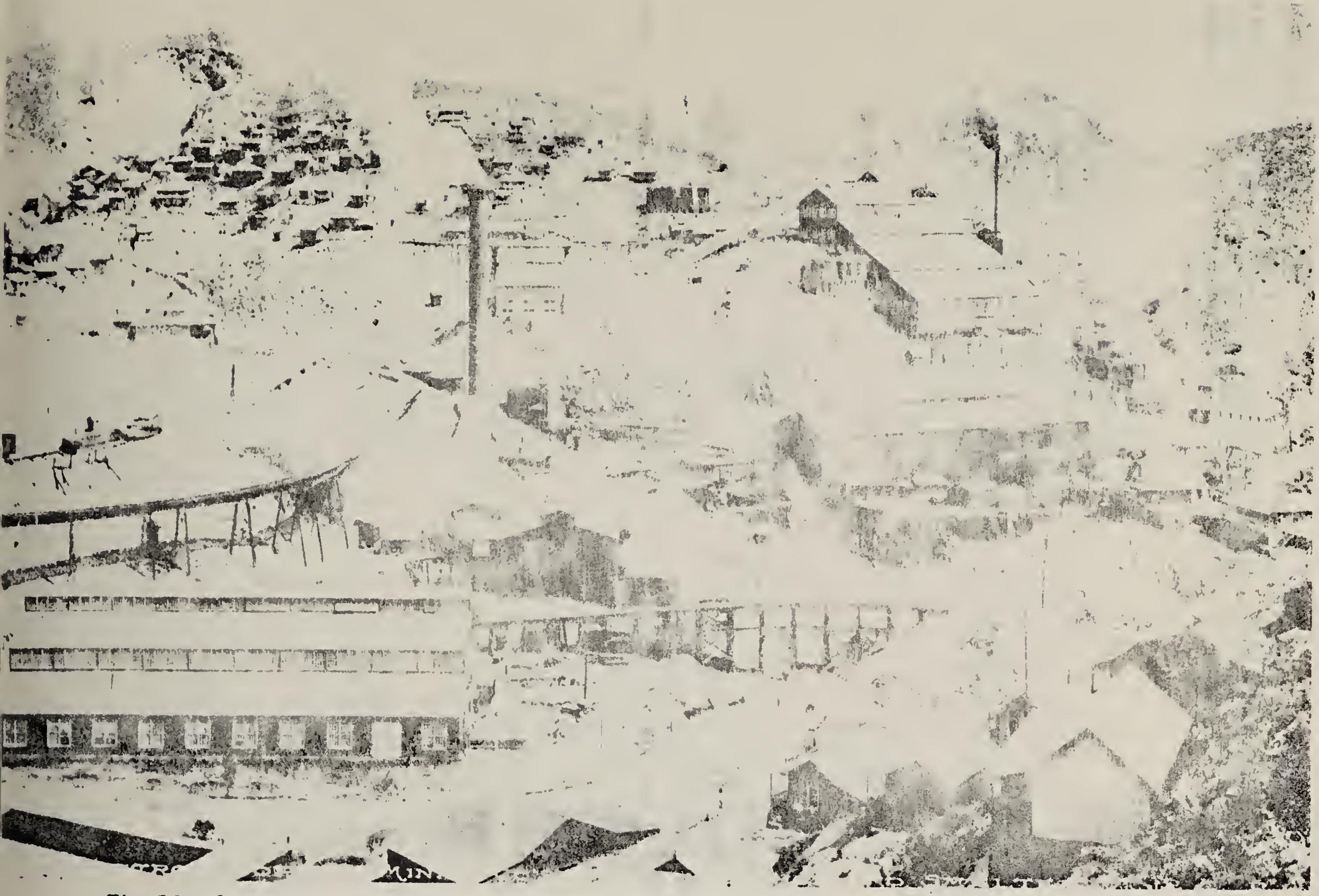


Fig. 98 - Gaseous wastes being dispersed into the atmosphere at the beneficiation plant and smelter of the Detroit Copper Company near Morenci, Arizona, about 1900. Waste gases containing high concentrations of sulfur oxides have long been a problem in the smelting of sulfide ores. Tall stacks that allowed dispersion to the winds were the earliest means of reducing local air pollution. (photo courtesy Arizona Pioneers Historical Society)

blasting. Probably the most common method of treating harmful gaseous wastes, in mines as in other activities, is by *dilution.* This is accomplished as local dilution by auxiliary ventilation systems or as dilution by main ventilation air streams. In other operations, dilution is obtained from natural atmospheric currents.

Dilution and the subsequent removal of atmospheric contaminants, be they gases or dust, are the most widely and successfully used procedures for the control of mine atmospheres. The use of ventilating air in sufficient quantity can accomplish several objectives. The dilution of contaminants to safe threshold limits can be achieved, as well as the removal of excess contamination from the immediate environment in the exhaust air. The lowering of temperatures and humidity by removal of excess heat and water vapor and the provision of a constant supply of fresh air are also obtained. Dilution, nevertheless, is usually used in conjunction with other atmospheric control measures, such as the proper maintenance of internal combustion engines to minimize the production of carbon monoxide and other noxious gases. Drilling is done wet to minimize the creation of dust, but sufficient ventilating air is also blown to the working face to keep the dust concentration down. In addition, water sprays and dust collectors are often used to remove dust from the air.

Pure, dry air is composed of oxygen (20.95 percent by volume and 23.02 percent by weight), nitrogen and inert gases (79.02 percent by volume and 76.74 percent by weight), and carbon dioxide (0.03 percent by volume and 0.04 percent by weight). In addition, normal atmospheres contain varying amounts of water vapor. Normal air is a mechanical mixture, the chief constitutents of which are oxygen, nitrogen, and carbon dioxide, accompanied by more or less water vapor and some dust. Normal mine air is air that is not

Table 18

PRINCIPAL GASEOUS WASTE PRODUCTS OF THE NONFUEL MINERAL INDUSTRIES

Product	Specific Gravity (Air = 1)	Other Physical Properties	Harmful Effects	Source	Maximum[a] Allowable Concentration (percent)	Fatal Concentration (percent)
Oxygen	1.1056	Odorless, colorless, tasteless	Non-toxic	Normal air	19.5 min.	less than 6
Nitrogen	0.9673	Odorless, colorless, tasteless	Asphyxiating	Normal air, rock strata	80.0	94
Carbon Dioxide	1.5291	Odorless, colorless, tasteless, suffocating	Asphyxiating	Breathing, rock strata, fire, blasting, internal combustion engine, any complete burning of a carbonaceous fuel	0.05	18
Methane	0.5545	Odorless, colorless, tasteless	Explosive, asphyxiating	Strata, blasting, internal combustion engine, organic decay	1.0	5 to 15 (explosive)
Carbon Monoxide	0.9672	Odorless, colorless, tasteless	Extremely toxic, explosive	Blasting, internal combustion engine, any incomplete combustion	0.01	0.03 (12 to 74 explosive)
Nitrogen Oxides	1.5895	Irritating odor, red-brown color, bitter taste	Toxic	Blasting, internal combustion engine, incomplete combustion	0.0005	0.005
Hydrogen Sulfide	1.1912	Rotten egg odor, colorless, acid taste	Toxic, explosive	Strata water, strata gas, blasting	0.002	0.1 (4 to 46 explosive)

Table 18 (Continued)

Product	Specific Gravity (Air = 1)	Other Physical Properties	Harmful Effects	Source	Maximum[a] Allowable Concentration (percent)	Fatal Concentration (percent)
Sulfur Dioxide	2.2636	Irritating odor, colorless, acid taste	Toxic	Combustion of sulfide ore, internal combustion engine, fire, blasting, burning of carbonaceous fuels	0.0005	0.1
Hydrogen	0.0694	Odorless, colorless, tasteless	Explosive, toxic	Electrolysis of acid water, blasting, batteries	—	4 to 74
Aldehyde	1.1700	Irritating odor, colorless, acid taste	Toxic	Internal combustion engine	0.0005- 0.001	?
Radon	7.665	Odorless, colorless, tasteless	Radioactive	Strata	300 mmc/1	?

Fire damp is methane + air (explosive)
Black damp is carbon dioxide + nitrogen + air (suffocating)
After damp is carbon monoxide + carbon dioxide + methane + oxygen + nitrogen + hydrogen (toxic—follows explosion)
White damp is carbon monoxide + air (toxic)
Stink damp is hydrogen sulfide + air (toxic)

[a] In working mine atmospheres.

Sources of data: J. J. Forbes and G. W. Grove, "Mine Gases and Methods of Detecting Them," *U.S. Bureau Mines Miners' Circ. 33* (1954), pp. 3-18; *Heating Ventilating Air Conditioning Guide* (37th edition; N.Y.: Amer. Soc. Heating Refrig. Air Cond. Eng., 1959), pp. 77-80; *Federal Mine Safety Code for Bituminous Coal and Lignite Mines*, Pt. I, U.S. Bureau of Mines (October 1953), pp. 29-30, and H. L. Hartman, *Mine Ventilation and Air Conditioning*, New York: Ronald Press, 1961, pp. 20-21.

Table 19
MAXIMUM ALLOWABLE CONCENTRATIONS OF DUST[a]

Mineral Component	Concentration in millions of particles per cubic foot of air
Silica	
250	250
crystalline quartz	$\%SiO_2$ + 5
crystobalite	20
tremolite	5
Silicates	
asbestos	5
mica	20
soapstone	20
talc	20
Portland cement	50
Graphite (natural)	15
"Inert" or nuisance particulates	50

[a] in working mine atmospheres

[b] Based on impinger samples counted by light field techniques.

Source of data: From *Threshold Limit Value for 1968,* The American Conference of Governmental Hygienists.

injurious to breath and does not contain dangerous portions of flammable or explosive gases. Mine air ordinarily contains considerable water vapor because most underground mines are below the water table. There are significant exceptions to this, of course. Relative humidities found in mines are from about 50 percent to over 90 percent. Exhaust air from mines is often saturated with water. Dust concentrations of one-half million to a few million particles per cubic foot are also common in a producing underground mine. Gases such as carbon monoxide, oxides of nitrogen, sulfur dioxide, hydrogen sulfide, and aldehydes are often produced by mining operations but *are seldom in detectable concentrations in the exhaust mine air.*

The United States Bureau of Mines regards air as unfit for men to breath if it contains less than 19.0 percent oxygen, more than one percent carbon dioxide, or a harmful amount of toxic gas.[52] It recommends that mines be ventilated with air containing not less than 19.5 percent oxygen nor more than 0.5 percent carbon dioxide and no harmful quantities of noxious or poisonous gases (i.e., not more than 10 parts per million of sulfur dioxide, 10 parts per million of hydrogen sulfide, 25 parts per million of nitrous oxide, 100 parts per million of carbon monoxide), one percent methane (explosive mixtures range from 5 percent to 15 percent, methane with over 12 percent oxygen), or 10 micromicrocuries per liter of radioactivity.

Most gases that are hazardous to miners are produced as a result of the mine operations (such as blasting), the running of internal combustion engines, the charging of batteries for

Table 20

PREVALENCE OF RADIOACTIVITY IN WESTERN MINES

Types of Mines Sampled	Radioactivity (micromicrocuries per liter of air)
Uranium mines	100 - 80,000
Lead mines	0 - 2,100
Lead-zinc mines	26 - 1,440
Clay mines	0 - 640
Gold-silver mines	40 - 402
Copper mines in Arizona	8 - 300
Coal mines	0 - 130
Tungsten mines	17 - 40

Source of data: P.W. Jacob and Allen D. Look *Occurrence of Radon in Some Western Mines*, the National Safety Congress, October 19, 1953.

mine locomotives, the burning of open lights, heaters, and fires, and the breathing of men and animals. Some dangerous gases are also produced from the oxidiation of sulfide minerals and some from the rotting of timber. Occasionally, dangerous gases issue from rock strata and from groundwater. Except for gases from mine fires, gases from most other sources can be effectively controlled with a nominal amount of ventilating air. In most instances, mine workers are affected by gases in infrequent accidents that usually occur in isolated places.

Dust is an ever-present and particularly insidious hazard to mine workers, because when airborne, it is largely unseen, its ingestion into the lungs goes unnoticed, and it takes many years to produce irreversible lung damage. Silicosis is a major occupational disease in the United States, and it is produced by dust containing free silica or quartz. Through the years, efforts have been made by health workers to establish maximum concentrations of dust below which ill effects on exposed workers would be effectively eliminated. These threshold limit values in millions of particles per cubic foot of air (mppcf) are published by the American Conference of Governmental Industrial Hygienists. The problem is diminishing, however. The overall silicosis prevalence rate in the metal mining industry for the 1958 - 1961 period was found by a recent study to be 3.4 percent or 476 cases out of 14,076 workers.[53] This is in marked contrast to rates revealed by earlier studies where as many as 60 percent of the workers showed evidence of silicosis and seldom were fewer than 25 percent afflicted.

Exposure to radon and its daughters has been widespread throughout the uranium mining industry. Radiation dosage from breathing a radon-containing atmosphere arises principally from radon daughter products accompanying radon in the air. Substantial portions of these daughter products are retained in the lungs. The two alpha particle emitting isotopes of these daughters are the principal direct source of radiation dosage.[54]

Dangerous mine gases have not been limited to any particular section of the country. Irrespirable gases have been noted to have occurred in the Rico and Cripple Creek districts, both in Colorado, the East Tintic district in Utah and in several Nevada mines.[55] Most of these gases were suffocating gases; some contained over 60 percent carbon dioxide, whereas others were almost pure nitrogen. Carbon dioxide is especially associated with limestone and chalk formations. Methane is commonly associated with carbonaceous materials, and, although often thought to be unique to coal mines, it has a widespread occurrence among non-coal mines. Troublesome accumulations have been found in gold mines at Grass Valley, California, as well as in quicksilver mines in California, in the Joplin lead-zinc district in Missouri, in the Picher zinc district in Oklahoma, in salt mines in New York and Louisiana,

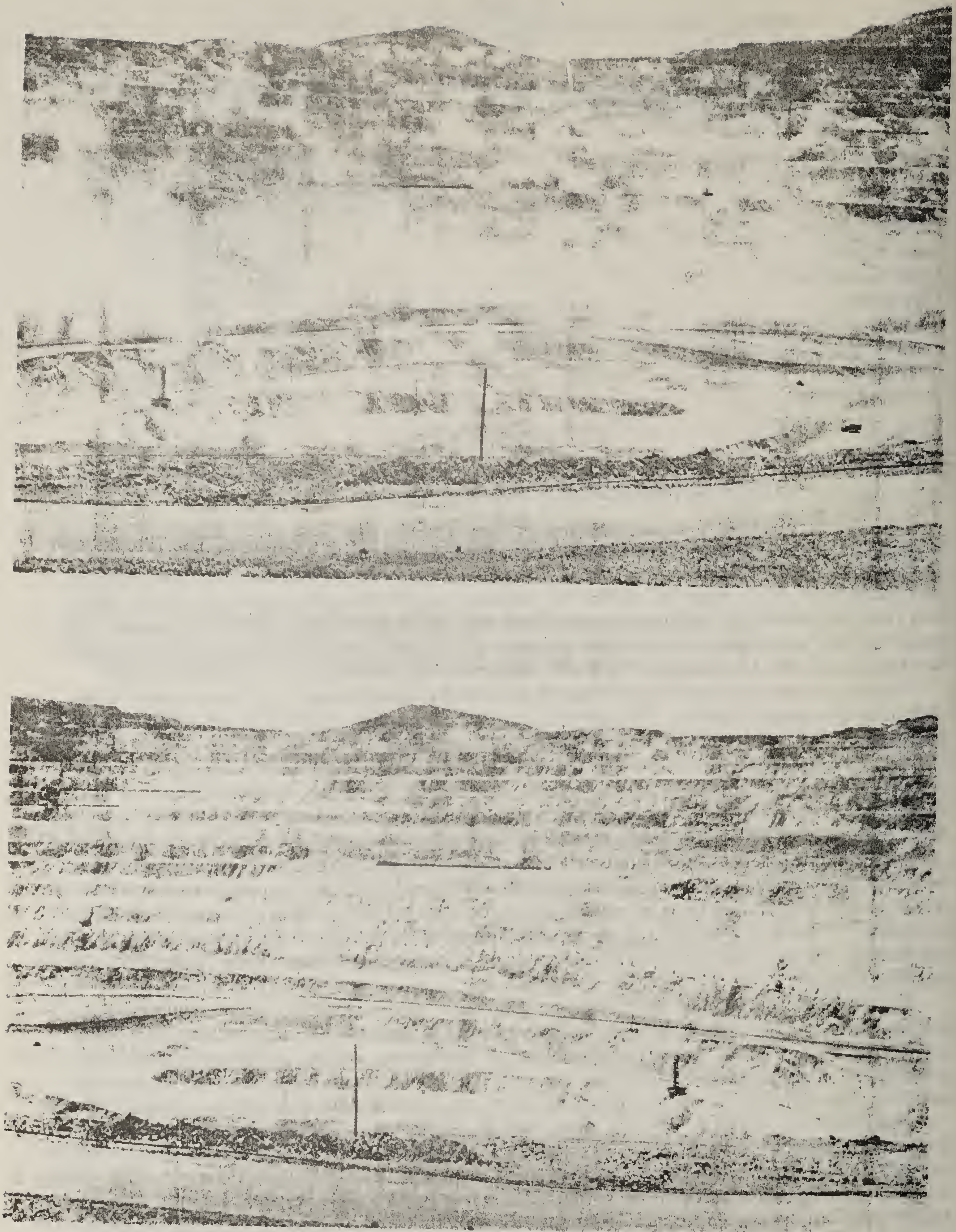


Fig. 99 - Dust is the principal atmospheric contaminant caused by mining operations. The usually large amount of dust visible in the upper photograph was the result of a large bench blast detonated just seconds before the picture was taken. The lower photograph is more typical of visible dust conditions during normal mining operations. In underground mining, however, the most harmful contaminants are invisible.

and in potash and gilsonite mines in Utah. Certain gases tend to be associated in origin with certain rocks and minerals. Because gases migrate readily through cracks and other channel-ways found in the earth's crust, however, they are frequently found in widespread and seemingly random distribution.

Mines that have been flooded and subsequently dewatered are often the source of suffocating atmospheres. Abandoned mines are also likely places to find oxygen deficient atmospheres. In the dead ends of mine openings, such as shaft bottoms, the tops of raises, and the ends of drifts and cross-cuts, air tends to become stagnant. In time, all or most of the oxygen may be removed from the air as the oxidation of exposed minerals occurs or as timber deteriorates. This leaves a nitrogen rich atmosphere that may or may not contain a high concentration of carbon dioxide from rotting of timber or sulfur dioxide from oxidized sulfides.

A study of silicosis prevalence rates between the Pacific Northwest and the Southwest showed almost identical rates. [56] The silica content of the dust in a mine is found to be much more important a factor in the prevalence of silicosis than the type of commodity produced. The government's 1958-1961 study of silicosis in metal mines found that there were only insignificant differences in silicosis prevalence rates among mines where the rocks have appreciable free silica contents. In certain iron mines and lead-zinc mines, however, the silicosis prevalence rates were one to 10 percent of those found in mines where the concentrations of free silica in the rocks is over five percent.

A study of radon occurrences in mines made by the Colorado Department of Public Health showed radon to occur in metal mines, clay mines, and coal mines, as well as in uranium mines. Being a gas, radon will migrate like any other gas so that it may be found widely separated from its parent source of uranium. Appreciable quantities of radon have been found in mines several hundred miles away from the nearest known deposits of uranium ore. It has been found, also, that the radon content of a few non-uranium mines approach the levels found in some uranium mines with similar conditions of ventilation.

Although mine fires in metal mines are not a major cause of accidents, they have, on occasion, caused great loss of life and property. According to United States Bureau of Mines records, during the period from 1932 to 1954, 93 metal and nonmetallic (except fuels) mine fires caused 13 fatal and 98 non-fatal injuries. This was only 0.06 percent of the total injuries that occurred at these mines during the same period.[57] Unless extinguished quickly, mine fires in timbered mines may quickly get out of control and are likely to be fanned by ventilating currents. The draft from a mine fire adds greatly to the normal ventilating pressures, often making it impossible to cut off the flow of fresh air to the fire area by ordinary means, such as by closing fire doors. Furthermore, because of the difficulty of reaching fires in underground mines, ordinary methods of fire fighting using chemical extinguishers and water are often not effective except when the fire is small and localized.

The most effective method yet developed for putting out mine fires that have gotten out of control is to completely seal the fire area from the atmosphere. Seals may be made of masonry, concrete, or wood plastered with mortar or plastic foam. Provisions are usually made for taking samples of gases behind the seal and for bleeding off excess pressure. The sampling of the gases behind a seal indicates the state of the fire and when combustion has ceased. Even though combustion ceases, if enough heat is contained in the sealed area, the fire may be revived when the seal is opened and fresh air admitted. Thus, unsealing fire areas is usually done cautiously. This commonly practiced method of mine fire fighting assures that under normal conditions, the adverse effects upon the atmospheric environment of even a major mine disaster are minimized. The adverse effects of normal mine operations are slight. Although huge volumes of fresh air are required for underground mining operations, this air is usually returned to the environment relatively unchanged except for a higher water vapor content. The very nature of noxious components of mine atmospheres makes their dilution before exhaustion from a mine an absolute necessity.

All mining operations, of course, are not underground, and surface mining activities also have effects upon the atmosphere. The principal air contaminant from surface mining operations is dust. Extreme dust control in open-pit mining operations is largely unnecessary, however, except in dry seasons and in the more arid climates such as these of the Southwestern United States. There, dust control practices are concentrated on critical material handling operations such as shovel loading and conveyor belt transfers. Water sprays are used to keep the broken rock on the benches in front of each shovel wetted to keep the dust down as the ore or waste is loaded into trucks or railroad cars. Haul roads are either sprinkled by water trucks or treated with oil or lignon sulfonate (a waste product created in the manufacture of paper) to allay dust. Dust produced at primary crushers is usually collected by an exhaust ventilation system and then trapped by a dust collector. In the mining stage itself, water is used for drilling, and in milling water is used to control dust during crushing. Water is also sprayed on tailings piles from time to time to reduce the hazard of dust.

2. Gaseous Waste Management in Advanced Processing

Mining operations, be they underground or open pit, have never been serious contaminators of the atmosphere. Most of the adverse atmospheric effects of mineral industry activity have come from beneficiation and advanced processing operations. Minerals reduction operations have been serious creators of noxious gases while beneficiation plants (particularly of industrial minerals) have often created severe dust problems. The smelting of sulfide ores and the production of elemental phosphorus have been two of the most important real and potential offenders in the West. Sand and gravel plants have usually been the most notorious air polluters among industrial minerals operations.

In the production of metallic sulfide minerals, internal methods are normally successful in controlling blasting noise and vibration, water pollution, and dust, but there is considerable visible air pollution from smelting. Such air pollution includes sulfur oxides, nitrogen oxides (also part of photochemical smog) and fine particulate fumes of solid particles.[58] Air pollution from smelters can for the most part, however, be controlled. The problem is that under most circumstances, costs are now too high, according to the United States Bureau of Mines.[59] Both sulfur trioxide and sulfur dioxide (which is invisible) can be controlled by several known processes.[60] They can most easily be turned into sulfuric acid before reaching the atmosphere, and this is being done at a number of smelters in the West.[61] National Lead Company's Titanium Division has successfully trapped the acid so produced in one of its plants using felt pads.[62] Unlike sulfur oxides, however, nitrogen oxides are not widely enough understood to control. Smoke (airborne solids) can be trapped, and high stacks are used to disperse other contaminants before pollution of the ground level atmosphere.

One example of an overall air pollution control program is that conducted by the American Smelting and Refining Company. ASARCO uses continuous metering to detect, measure, and record amounts of sulfur dioxide in waste gases in conjunction with various preventative air pollution measures. The tall smelter stack (826-feet high at El Paso, Texas) is a notable air pollution control device. Bag houses are used which remove between 99.0 and 99.5 percent of fine solid particles in gaseous wastes from smelting. Electrostatic precepitators also collect solid particles suspended in smelter gas. The use of sulfur dioxide as a commercial product is continually studied, and several beneficial uses have been discovered. In addition, weather stations check climatic conditions for predicting the necessary smelter control practices. Each of the company's smelters takes air samples and these are monitored through telemetry at the firm's El Paso, Texas, and Tacoma, Washington, plants. Portable noise analyzers, photoelectronic dust counters, and portable atomic absorbtion spectrophotometers are also used in controlling the atmospheric environment.[63]

Atmospheric quality control is not merely a recent development with most metals producers. For example, at the American Smelting and Refining Company air quality control was begun in 1914 in cooperation with the United States Department of

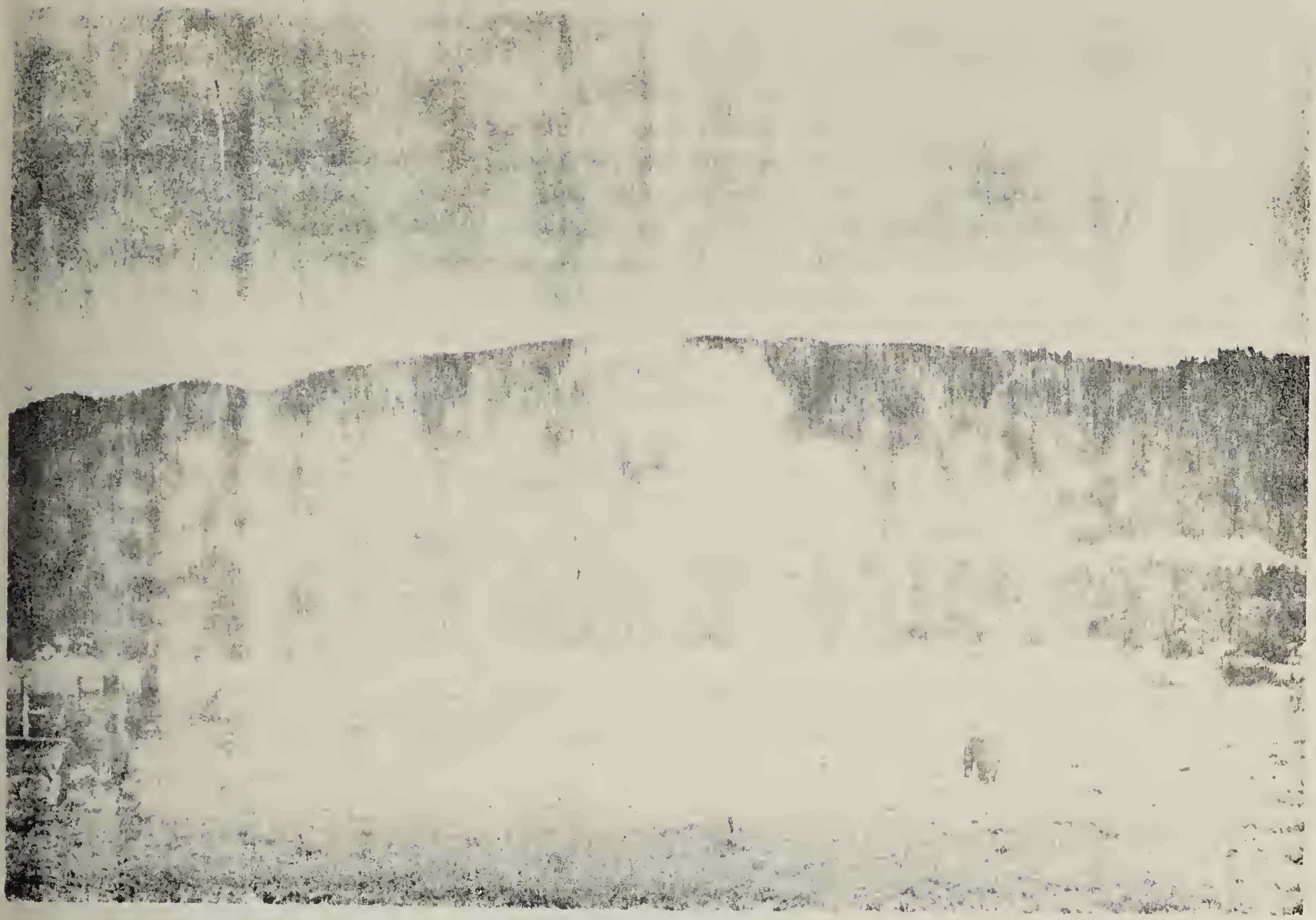


Fig. 100 - Gaseous waste dispersed into the atmosphere at the nickel smelter of the Hanna Mining Company near Riddle, Oregon. Water vapor forms a significant portion of the visible effluent from such operations. In the background is Hanna's Nickel Mountain Mine, at present the only significant source of primary nickel in the United States.

Agriculture. Gaseous waste management research was begun in response to farmers' claims that smelter emissions were harmful to their crops. In 1945 the company's department of hygiene was formed to enable supplemental work on air quality and industrial hygiene. It has since grown to include considerations of wall colors, maximum noise levels, and light and dust control, all as part of the total working environment. Virtually all other major metals producers have similar programs, many of them of long standing.

Phosphate producers have also been conscious of the potentially harmful effects of the gaseous wastes created in their operations. The principal objection to this industry is the fluoride and sulfur oxide discharged in the air. In Montana, in fact, the plant of the Rocky Mountain Phosphates, Inc. was ordered closed by federal authorities under the Clean Air Act until flouride emissions were down to permissible state levels.[64] Florida phosphate companies, however, have reduced fluoride emissions from processing plants by 90 percent in recent years as have other phosphate producers in the Western Field. Florida producers recently spent $50 million in 10 years on air and water pollution control measures, and regularly spend $6 million per year on maintenance of control systems.[65] Florida producers are still studying sulfur oxide emissions for their control. Monitors check the amounts of such gases emitted and have found that they do not normally exceed regulation limits.

Air pollution from cement plants can be quite suffuse or negligible, depending on treatment given to the plant's waste gases. There is a great concern over the problem within the industry, however, and much has already been done. The problems incurred in an analysis of dust collection systems in the cement industry and their various merits have been discussed at the annual conventions of the National Limestone Insitute, and articles in technical journals are common. In one such article, one author has expressed the feeling that inadequate knowledge of dust collection methods has caused a loss of money and the ruination of machinery.[66]

The operation of sand and gravel beneficiating plants has in many instances been a locally severe and particularly obnoxious source of various adverse effects upon the environment. Air pollution has usually been the most noticeable of such effects. But such activity has not been typical of the entire industry, and many firms, because of local legislation or an increased awareness of public opinion, have eliminated many of the problems caused by uncontrolled gaseous wastes. One such firm, Eugene Sand and Gravel Inc., operating near Eugene, Oregon, has a sand and gravel pit which incorporates a system of channels and dikes which prevents siltation problems and water pollution. The area is screened with trees, and the worked-out area is reconditioned for other uses. Round gravel, concrete sand, crushed gravel, and asphalt fines are processed, stored and loaded separately. Cyclones and scrubbers are employed for solving dust recovery and air pollution problems. The asphalt plant also has dust collectors.[67]

In Alabama, another firm has a typical dust collecting system consisting of a 45,000 cfm. fan, twin cyclone collectors, two spiral spray chambers, and a steel stack with another cyclone at its base and sprays part way up its height. The asphalt plant fines go to the final cyclone and stack, while the course material goes to the spiral chambers and thence to waste. Each fan has dampers so that the draft can be cut down, if desired, to collect finer dust. Water containing the collected dust flows from the two spray chambers to a settling basin.[68]

Not all dust control measures achieve complete or phenomenal reductions in undesirable emissions. At Santee in South Carolina, dust collection equipment either disposes of the dust collected by a cyclone or returns it to the kiln by a Fuller dust insufflation arrangement. This return reduces costs, as only one additional process is needed to convert the dust to clinker. At the installation there is eight percent less dust expected.[69]

Similarly, not all methods of dust control have been effective in all places. One firm, for example, had a severe dust pollution problem. Water sprays at various strategic points had been used, but filtering was necessary before spraying and the system was not operative in below 32 degree F. weather. Furthermore, the higher water content reduced screening efficiency. The firm first installed a dry dust collection system involving ductwork, several fans, and cyclone type collectors, but the necessary maintenance was excessive, and the dust plume from various cyclones was objectionable. The company added an industrial fan providing 4,000 cfm. of air, bag-type dust collectors, a collected dust storage unit, and related hooding and ductwork. The cost for the entire system was about $12,000. It did, however, result in several benefits. Turnover in operating personnel was drastically reduced. Plant safety was improved and there was a 100 percent improvement in visibility. Furthermore the dust collection system yielded a saleable commodity.[70]

Still other methods have also been used. One variation for solving dust problems was that employed by the Jamison Block Marble Company, at its Harrisburg, Virginia, plant. A special chemical compound and water effectively reduced dust without excessive moisture, as little water was needed with this penetrating additive. A metering device and spray system were installed, and heat tapes wrapped around piping prevented freezing of water. Costs were defrayed by increasing production time from three to five days a week.[71]

When another firm began planning for its Michigan cement operation near a resort area, local fears were allayed be the company's consulting state and local officials on methods to reduce air pollution and prevent defacing of the Lake Michigan shore line. Air pollution was 99 percent controlled and the quality of the plant's gaseous effluent was made better than that demanded by the air quality control code for the township in which it operates. At the operation, limestone, shale, and iron ore are stockpiled in storage buildings rather than in the open air. Blasting is checked by a seismograph to keep noise and vibration disturbances to a minimum.[72]

Throughout the country, a cooperative research effort is being made by lime producers in reviewing technical data for determining the feasibility of air pollution controls. Lime dust is highly visible but is not know to be a serious health hazard. Those cement and lime

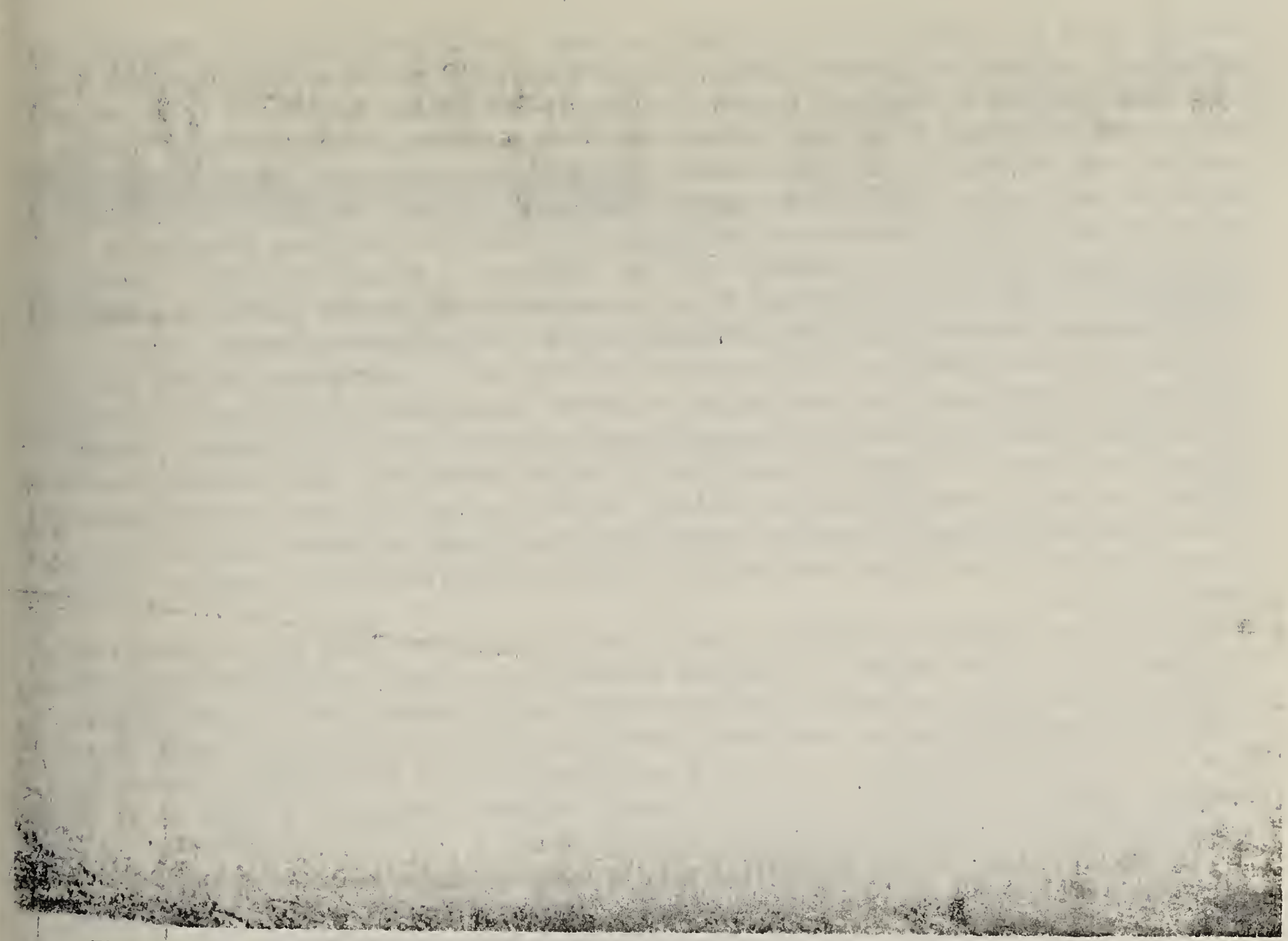


Fig. 101 - Gaseous waste being dispersed into the atmosphere by two copper smelters in Southern Arizona. Waste gases from smelters processing sulfide ores are highly visible for great distances, but normally the most severe adverse effects are caused by invisible components in the immediate area of the smelter. Newer smelters contain elaborate dust control equipment that removes practically all solid particles from gaseous effluent. In addition, increased efforts are being made to remove sulfur oxides and use them in the manufacture of sulfuric acid. (photo courtesy T. J. McCleneghan)

plants using coal as fuel are different from those relying on other sources of fuel, however, since sulfur emissions from burning coal present problems similar to those of the copper, lead-zinc, and coal industries. One chemist involved in such research has stated, "If we could forget the cost and the other difficulties in designing, installing and using this equipment, we could virtually eliminate air pollution. However, economics, normal wear and tear, maintenance and deterioration, plus other factors, make this impossible."[73]

Some of the new industrial minerals plants, using modern dust control equipment, have gained an efficiency of more than 99 percent in eliminating solid particles from gaseous wastes dispersed to the atmosphere. Older plants using various types of equipment normally have much less efficiency in dust control. Those using fabric collectors operate between 95 and 99.9 percent efficiency, while those using wet methods achieve efficiencies between 90 and 99 percent. Electrostatic precipitators can remove as much as 99.5 percent of the dust from gaseous emissions, but depending on particle size, shape, and composition can let as much as 20 percent of the dust escape. Mechanical collectors are least efficient, ranging from efficiencies as high as 95 percent down to 70 percent.

3. Summary

Contaminants of mine air are defined as any undersirable substance not normally present in air or any normal atmospheric component which may be present in an excessive amount. Based on their physical state, most impurities are classified as gases or aerosols.

Harmful gases and vapors are those that are toxic, suffocating, explosive, corrosive or radioactive. Aerosols are airborne solid or liquid particulate matter existing as mists, fogs (very small particles of liquids or mixtures of liquids and solids), or as dusts. These last are mechanically generated solid particles resulting from such operations as drilling, blasting, crushing, and ore handling. They are usually microscopic in size with an average diameter of about one micrometer (1/25,000 of an inch). Fumes are condensed vapors or solid materials sometimes produced in chemical and metallurgical operations. Most fume particles are less than one-half micrometer in diameter and are difficult to remove by filters. Smoke is composed of visible aerosols given off by a burning substance, usually carbon. In addition, harmful gaseous emissions may contain organisms such as virus, bacteria, pollen, spores.

Gaseous contaminants are of common occurrence in underground mines and in metallurgical operations. They vary widely in source, composition, and amount, but some are invariably present. Vapors and fumes are usually associated with metallurgical operations and seldom occur in dangerous quantities in mining operations. Mists and fogs occur naturally whenever vapor, laden air is suddenly cooled, causing the vapor to condense and to form droplets of liquid. This often occurs when warm moist air enters a cold mine shaft. Exhaust from rock drills often produces fog. Water-vapor fogs are more a nuisance than a hazard, however.

Dusts are of common occurrence both in and out of mines. Most mine operators pay special attention to the control of dust, but because *dust is largely invisible* and its harmful effects to the lungs are so long in appearing, many mineral industry workers unfortunately do not take the precautions or use the safeguards normally afforded them. Usually there is little or no smoke produced in a mining operation. Exhaust from internal combustion engines produces a negligible amount of smoke. Organic contaminants seem to be less prevalent in mine air than in normal surface atmospheres.

Compared to many manufacturing operations (particularly in chemical processing), mineral industry operations have relatively slight influence on the atmospheric environment. Significant effects do result from metals reduction (including phosphorus) operations and from industrial minerals beneficiation and processing. Pollution control measures are generally available, but they are costly.

Fig. 102 - Gaseous waste containing significant proportions of hydrogen sulfide dispersed into the atmosphere by a paper mill just west of Missoula, Montana.

Fig. 103 - Gaseous material containing significant amounts of hydrogen sulfide dispersed into the atmosphere from natural volcanic vents in the "Sulphur Works" area at Lassen Volcanic National Park in Northern California.

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CHAPTER 13

MINERALS AND THE LAND

Does the utilization of nonfuel mineral resources have any measurable effect upon the use of land as surface?

A. LAND STATUS IN THE MINERAL INDUSTRIES

The lands currently used in the production of nonfuel mineral commodities have been acquired by their present users in a variety of ways. The most important method used, however, has been by direct location on federal lands under the provisions of the Mining Act of 1872 and related state legislation. In a survey of a representative sample of large and small producers of nonfuel minerals conducted in 1968, approximately 30 percent of the mineral land area held by these producers had been obtained by direct location on federal lands. Almost 11 percent had been obtained by the purchase of patented mining claims and a little more than eight percent through the purchase of unpatented mining claims. (See Table 21.) State land leases accounted for less than eight percent, while federal land leases provided less than 12 percent. Private land leases were used in obtaining another 12 percent. A significant share (10 percent) had been acquired through merger or partnership. Leases on Indian lands and land exchanges have provided relatively insignificant proportions of the nation's mineral lands.

Other methods of acquisition were used by mineral producers in obtaining land for purposes other than those directly involved in mining operations. As shown in Table 22, almost a quarter of the total acreage used for such purposes was acquired from private landowners land by purchase. Another 17 percent was obtained by leasing state-owned land. Less than 12 percent was acquired through federal land leases, and a little more than nine percent through land exchanges. Significantly, approximately eight percent of the land acquired by present mineral producers *for nonmineral purposes* had been acquired by direct location on federal lands. This is an indication of the relative importance of the millsite (see Chapter 16) as a provider of land for auxiliary purposes. Curiously, almost none of the "non-mineral" land in the sample had been obtained by merger or partnership.

Lands owned by minerals producers currently operating in the United States that are both directly over valuable mineral deposits and adjacent to the deposit but necessary for mining operations have been acquired in similar ways. More than 55 percent of the land situated directly over orebodies has been acquired through the mineral location system, while only about 15 percent has been acquired through the federal leasing system. Private lease land and state lease land, however, comprise almost 20 percent of all such land. A somewhat lesser proportion (16 percent) of the land peripheral to orebodies but needed for mining operations has been so acquired. Other means of land acquisition including outright purchase, land exchanges, and other arrangements account for more than 18 percent.

Public land obtained under the mineral location system has also provided for more than half of the surface area presently used for waste storage and dump leaching by minerals producers in the United States. More than a fourth of all land so used, however, has been acquired by agreements outside of the federal or state land systems. The considerable portion of such land acquired through the mineral location system can be explained in large part by the widespread practice of using old excavations for the storage of waste material created by current mining operations.

The mineral location system has not been a substantial factor, however, in the acquisition of land by minerals producers for surface plant sites. Despite the mill site provision of the Mining Act of 1872, only eight percent of the land so used by existing minerals producers has been obtained under the minerals location system. Private lease land accounts for almost three-fourths of all land area presently used for the construction of beneficiation and advanced processing plants, as well as necessary surface plant facilities such as shops and offices. Curiously enough, a somewhat different situation exists with

Table 21

MEANS OF ACQUISITION OF LAND FOR MINERAL RESOURCE UTILIZATION IN THE UNITED STATES

		Sample[a] Acres	Sample[a] Percentage	Number of Respondents[b]
1.	Direct location on federal lands	88,633	30.5	28
2.	Direct location on state lands	0	0.0	0
3.	Federal leases	34,340	11.8	6
4.	State land leases	22,873	7.9	13
5.	Indian land leases	1,315	0.4	2
6.	Private land leases	28,984	10.0	23
7.	Private lease with option to buy	5,066	1.7	9
8.	Purchase of unpatented claims	23,996	8.3	14
9.	Purchase of patented claims	30,716	10.6	21
10.	Land exchange	300	0.1	2
11.	Merger or partnership	29,349	10.1	6
12.	Other means	18,846	6.5	19
13.	Unkown	6,000	2.1	1
	TOTALS	290,418	100.0	—

Total number of respondents: 78

[a] Data from a representative sample of large and small metallic and nonmetallic mineral producers in the United States surveyed in 1968 by the Division of Economic and Business Research, The University of Arizona.

[b] Some respondents obtained land by more than one method.

respect to that land acquired by existing minerals producers for company-owned, mining-related residential and commercial structures. Almost a third of such land currently used in this manner is on patented mining claims. The importance of patented claim land undoubtedly has arisen from the practice in many areas of placing residential and commercial structures (and in a few cases, entire towns) on inactive waste storage dumps. The traditional practice followed by miners in building their homes as close as possible to the mine has also been a factor.

Buffer zones, although not in widespread use in the mineral industry, have been acquired largely through the mineral location system. In fact, almost 90 percent of the land used for buffer purposes is on patented or unpatented mining claims. The leasing systems, on the other hand, have provided only 1.5 percent of the land used currently for this purpose. This heavily unbalanced relationship is undoubtedly due to the fact that much of the land used for buffer zone purposes is, in reality, land that is considered potentially valuable for mineral uses but has not yet been developed for mining. This accounts for the relatively high percentage of such land (more than 58 percent) that falls in the unpatented claim category. The small amount of lease land so used is undoubtedly the result of the high cost of such land compared to its relatively unproductive use as a buffer zone.

Almost half of all land currently used by minerals producers in the United States was acquired prior to 1930. More than a fifth of the land used by mineral producers, however,

Table 22

MEANS OF ACQUISITION OF LAND FOR AUXILIARY OR NONMINERAL PURPOSES BY ACTIVE MINERAL PRODUCERS IN THE UNITED STATES

		Sample		Number of Respondents
		Acres	Percentage	
1.	Direct location on federal land	13,515	8.1	11
2.	Direct location on state land	320	0.2	1
3.	Purchase of federal land	5,821	3.5	4
4.	Purchase of state land	12,287	7.4	4
5.	Purchase of private land	41,255	24.7	28
6.	Federal lease	19,362	11.6	4
7.	State lease	28,246	16.9	7
8.	Indian lease land	4,825	2.9	1
9.	Private land leases	2,005	1.2	7
10.	Private lease with option to buy	11,200	6.7	3
11.	Land exchange	15,339	9.2	5
12.	Merger on partnership	2	0.0	1
13.	Other	12,687	7.6	8
	TOTALS	166,864	100.0	

Total number of respondents: *66*

[a] Data from a representative sample of large and small metallic and nonmetallic mineral producers in the United States surveyed in 1968 by the Division of Economic and Business Research, The Unitersity of Arizona.

[b] Some respondents obtained land by more than one method.

has been obtained since 1961. This includes land acquired as unpatented mining claims, as well as land acquired through the patenting of claims and public, state, and private land leases.

Table 23

CURRENT STATUS OF MINERAL LAND CONTROLLED BY NONFUEL MINERALS PRODUCERS IN THE UNITED STATES

		Land Actually Over the Orebody or Mineable Mineral[a]		
		Acres	Percentage	Number of Respondents[b]
1.	Patented claims	32,834	20.5	35
2.	Unpatented claims	56,779	35.6	23
3.	State lease land	12,011	7.5	10
4.	Federal lease land	24,267	15.2	6
5.	Private lease land	19,521	12.2	16
6.	Other	14,340	9.0	13
	TOTALS	159,235	100.0	

Total number of respondents: *75*

[a] Data from a representative sample of large and small metallic and nonmetallic mineral producers in the United States surveyed in 1968 by the Division of Economic and Business Research, The University of Arizona.

[b] Some respondents obtained land by more than one method.

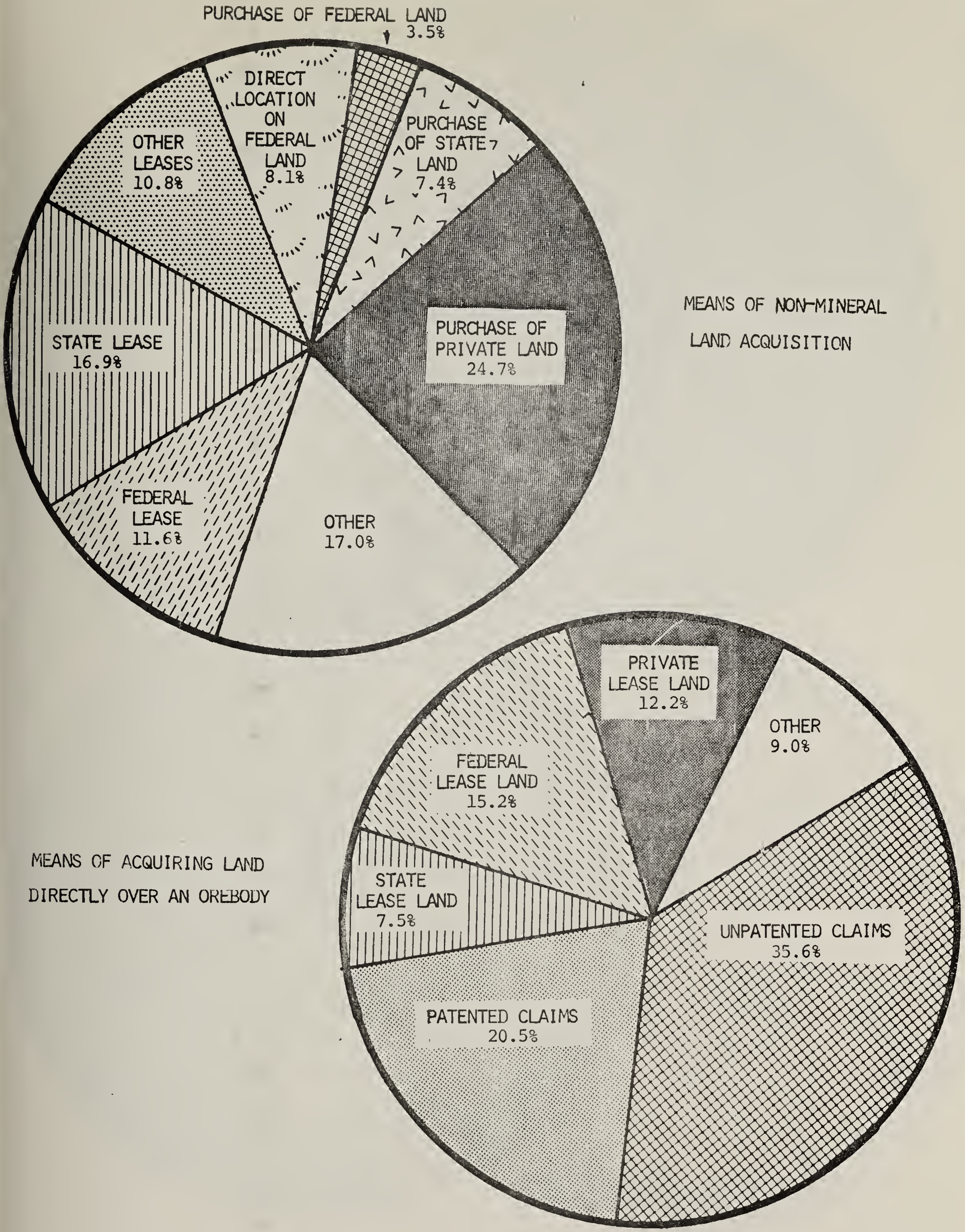


Fig. 104 - Land acquired by existing mineral producers has been obtained in a variety of ways. Although more than half the land directly over valuable mineral deposits has been obtained through the mineral location system, various leasing arrangements have also been used. The lands used for purposes other than actual mining have been obtained in a greater variety of ways.

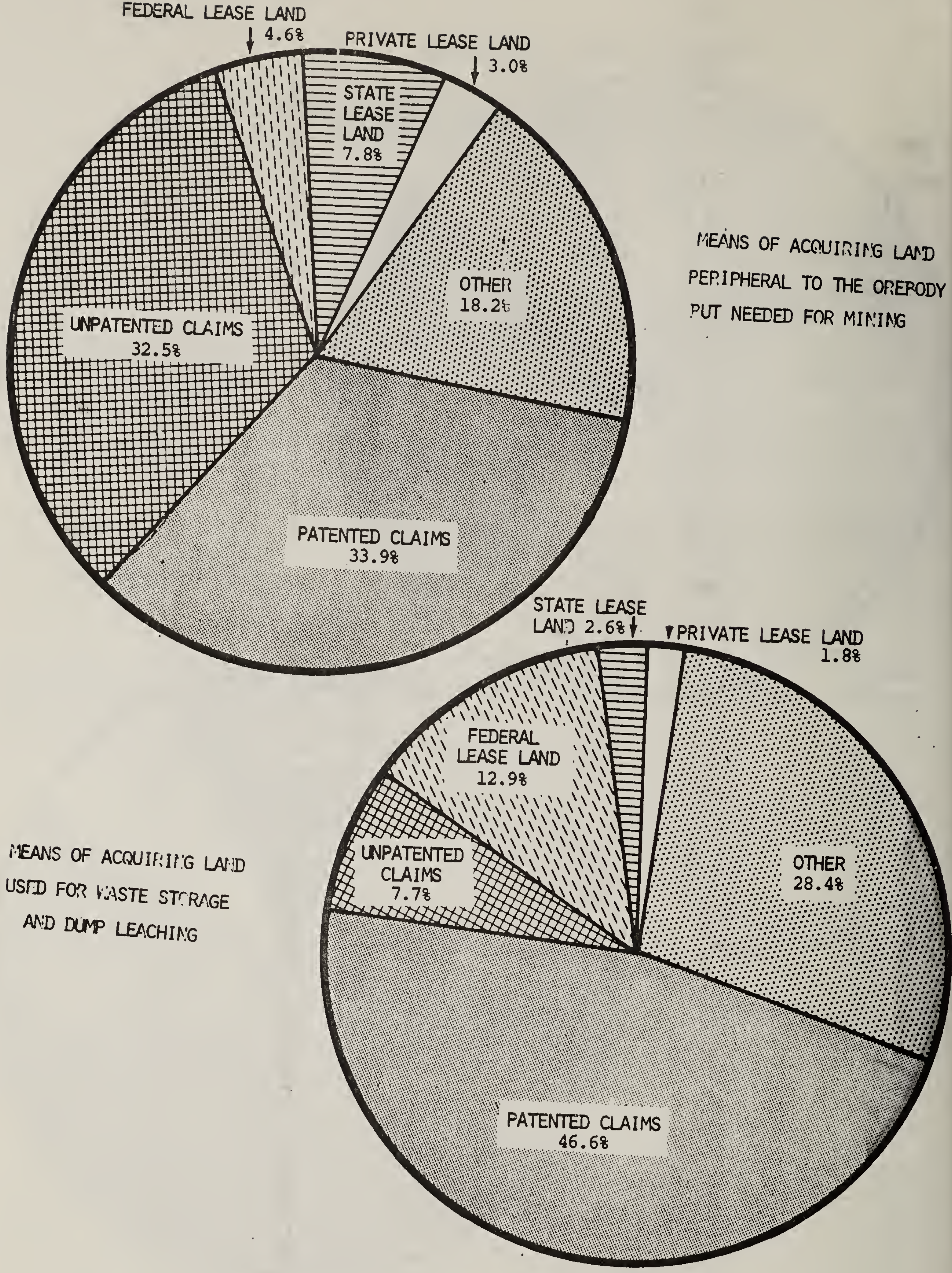


Fig. 105 - Approximately two-thirds of the land held by existing minerals producers that is peripheral to the mineral deposit mined but needed in mining has been obtained through the location system. More than half of the area used for waste storage and dump leaching has been acquired in the same manner.

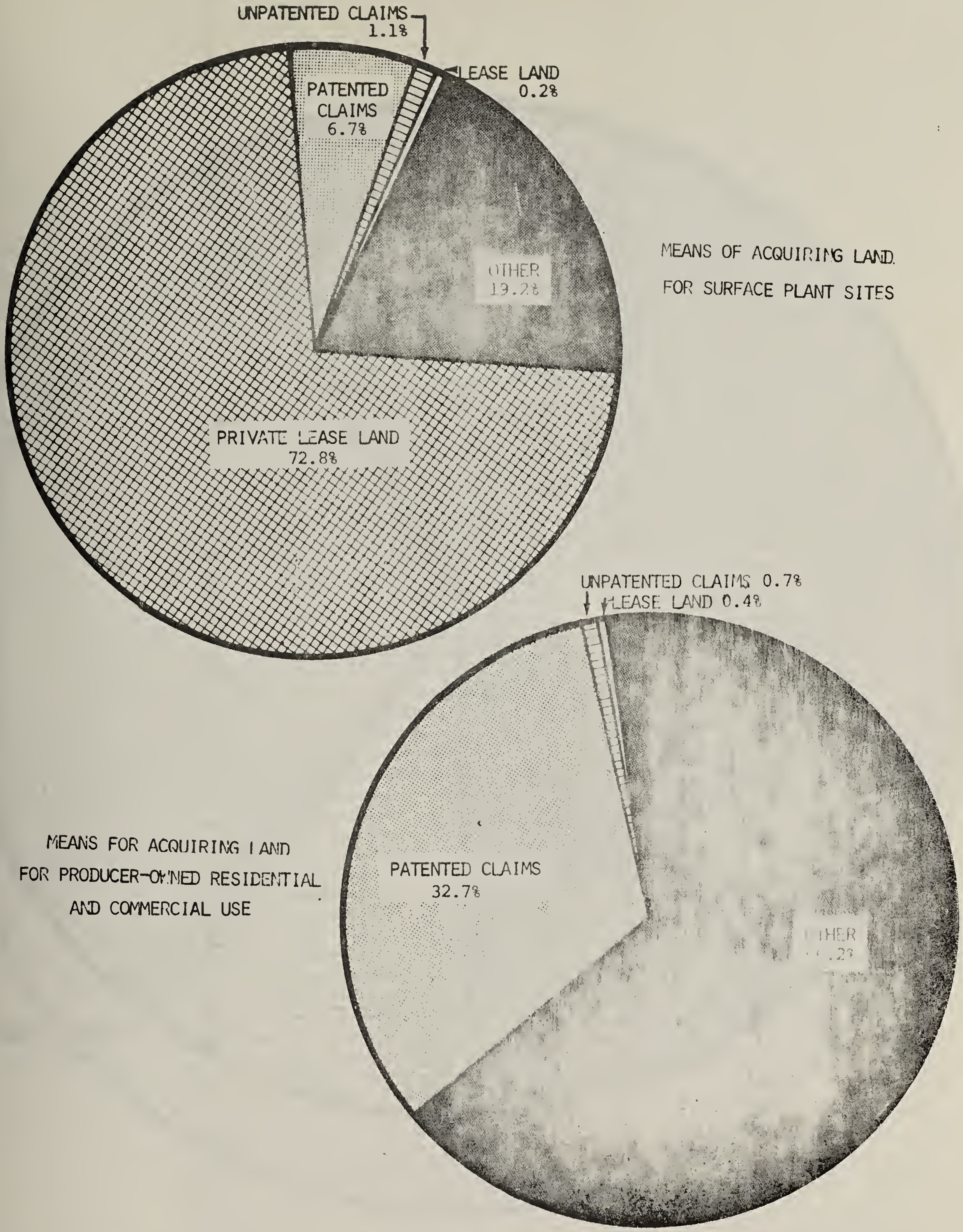


Fig. 106 - Almost all of the land used for surface plant facilities by existing minerals producers has been obtained through non-federal sources. Nearly one-third of all residential and commercial areas adjacent to mining operations, however, are on patented claims.

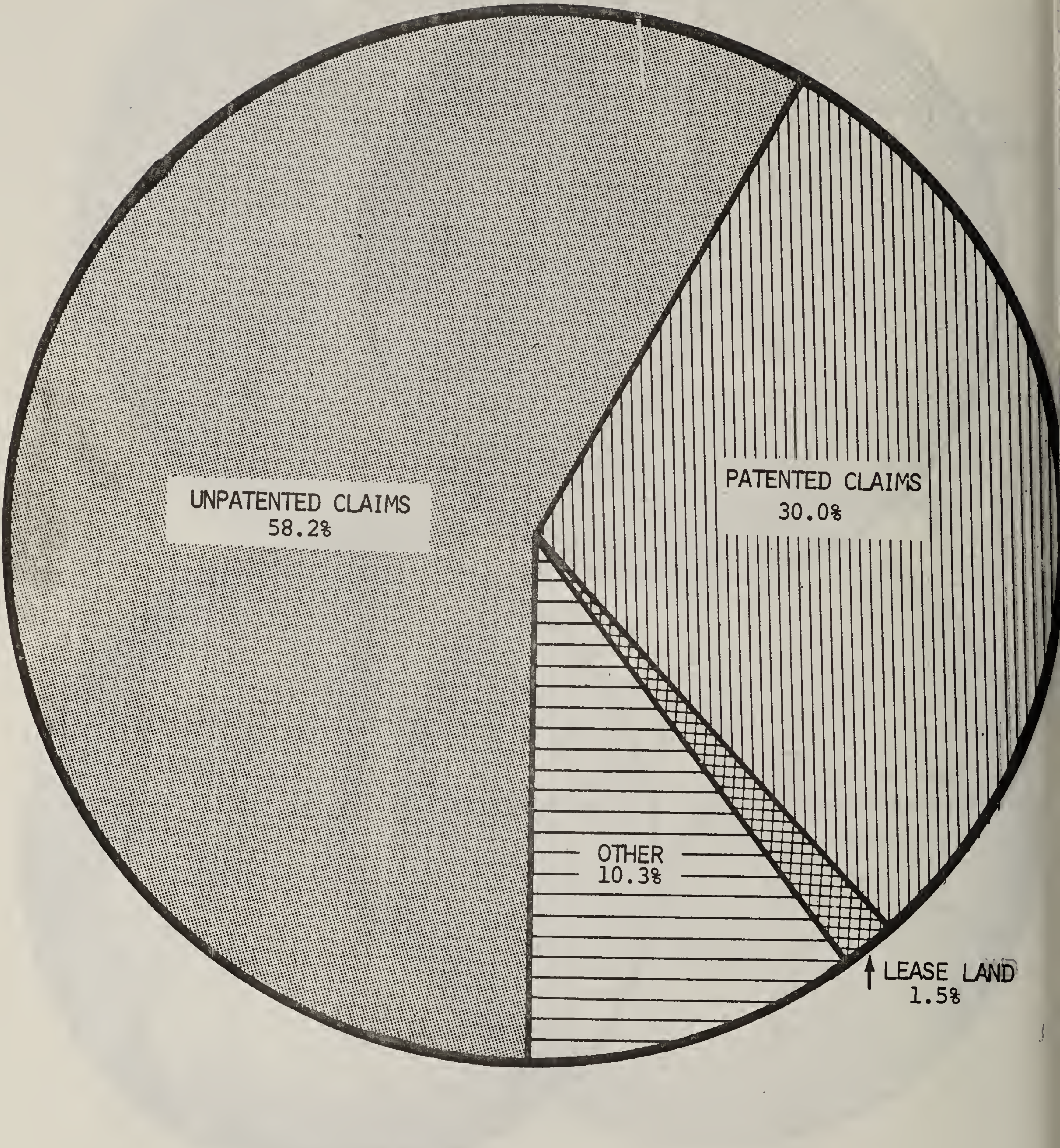


Fig. 107 - Means of land acquisition for buffer zones. While the deliberate use of buffer zones around existing mining operations is not common, those that exist are mostly on land acquired under the mineral location system. Many of these areas are actually over mineral deposits, but are being held for future operations.

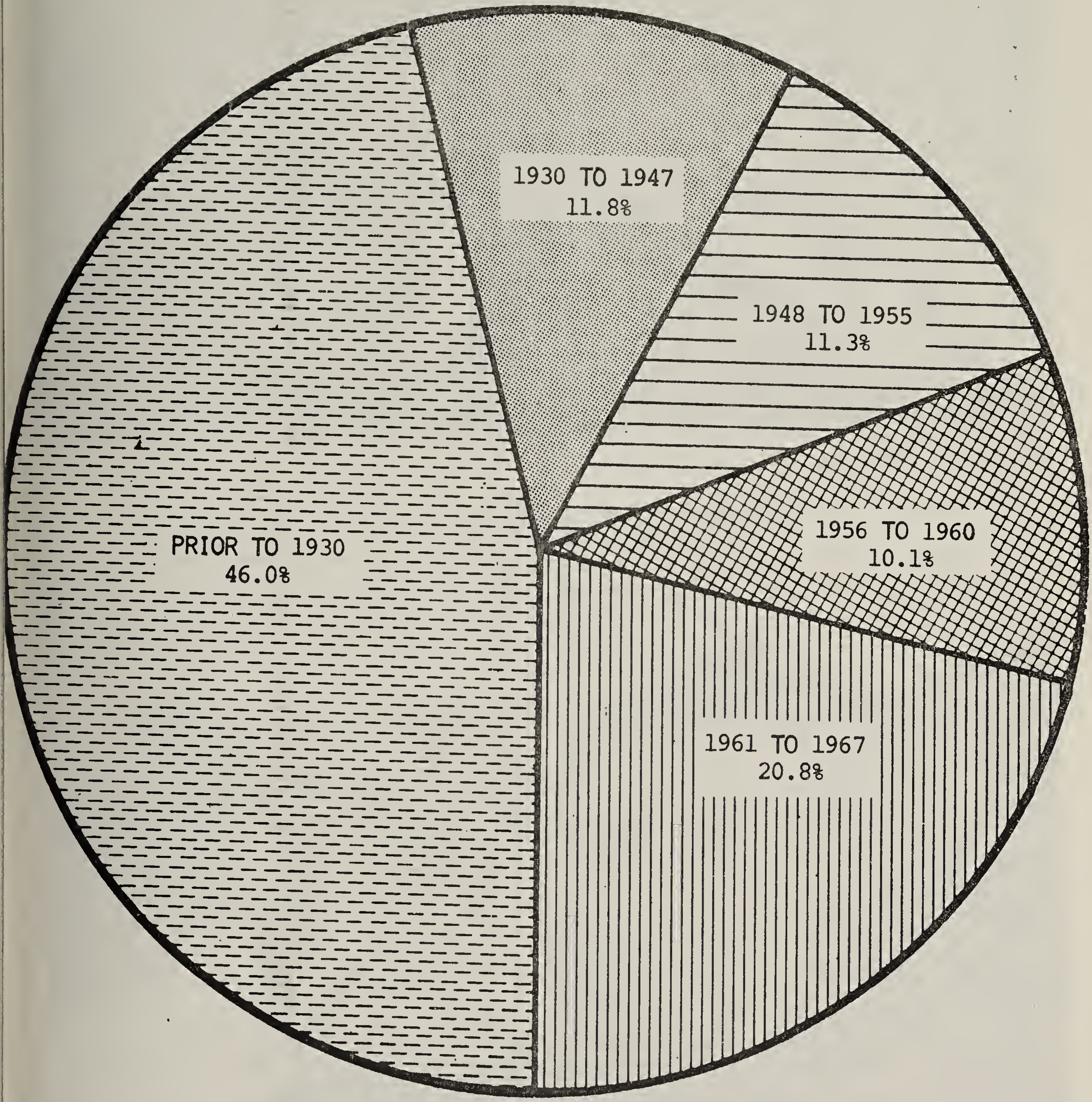
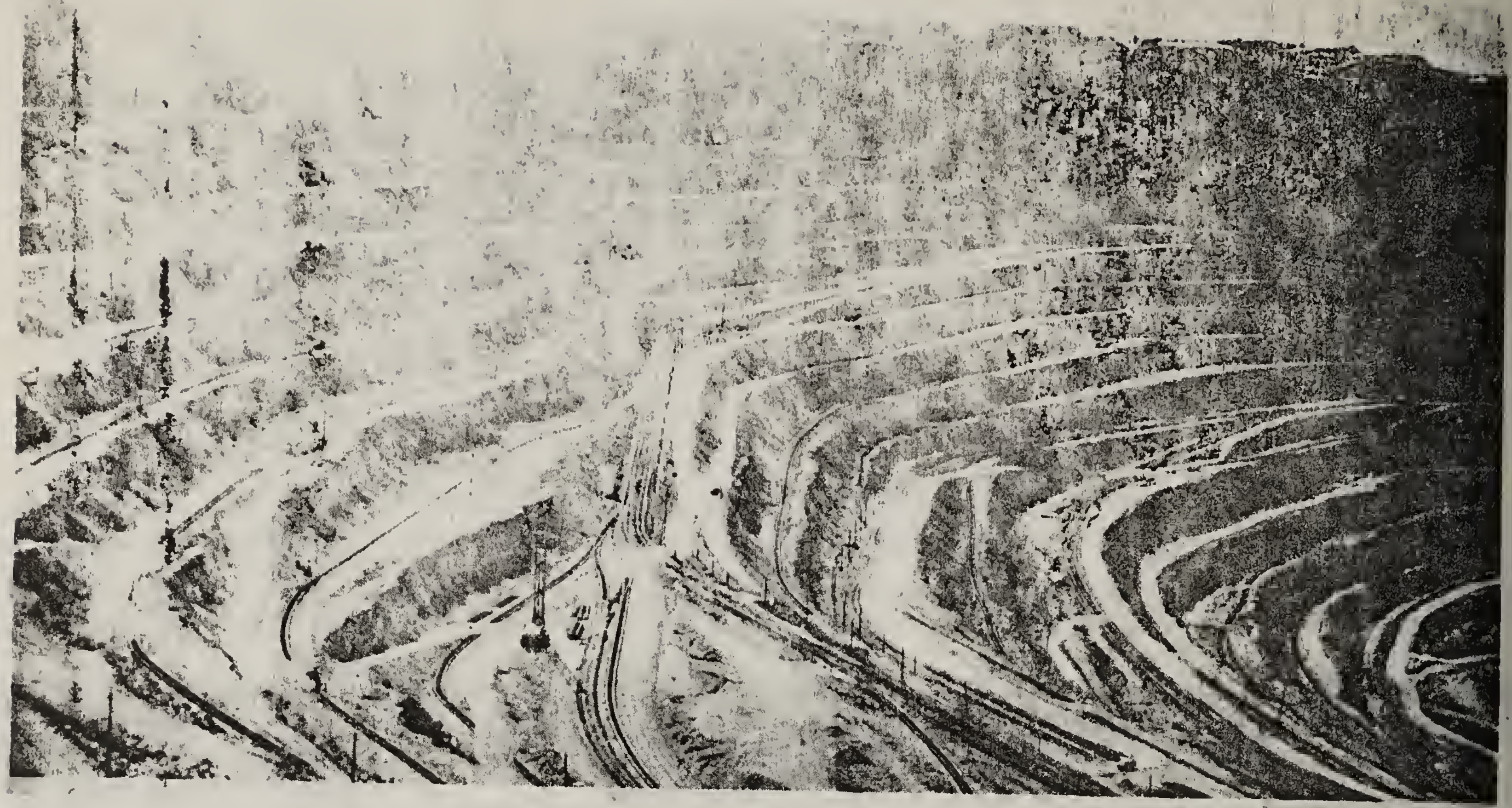


Fig. 108 - Almost half of the land held by existing mineral producers in the United States was acquired before 1930. Approximately 20 percent has been obtained since 1961.



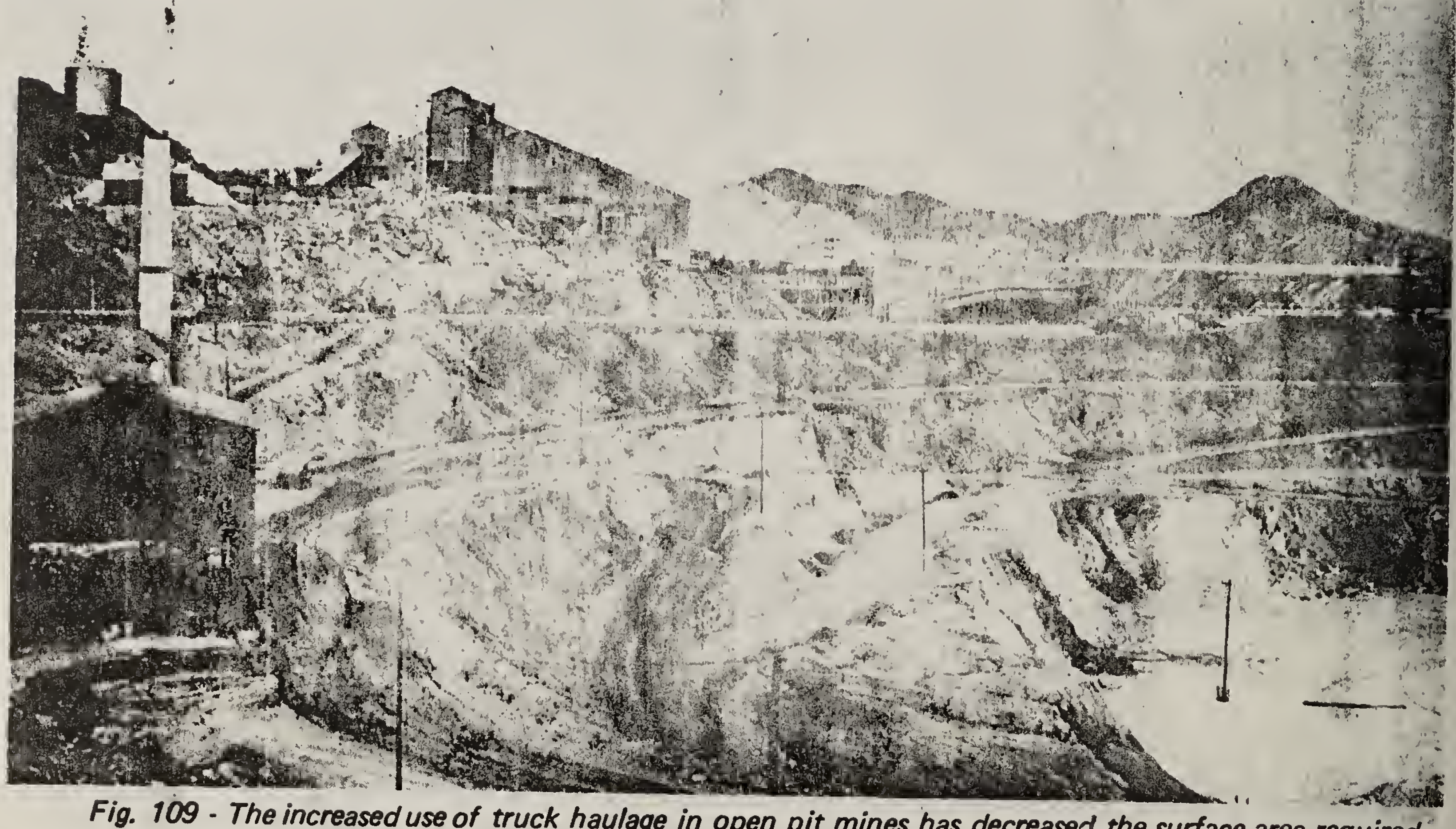


Fig. 109 - The increased use of truck haulage in open pit mines has decreased the surface area required for mining large, low-grade orebodies. As shown in the upper photograph, rail haulage demanded considerable lateral extension as a pit deepened in order to provide a low enough incline for the operation of trains. Trucks can negotiate steeper grades, however, and permit steeper overall pit slopes, using less surface area for a given depth of ore.

B. LAND USE BY THE MINERAL INDUSTRIES

Based on a survey of land use by active mineral producers in the United States in 1968, the average mine had a total land requirement of about three-fourths of an acre for every ton of ore mined each day. As shown by Figure 111, however, such a ratio was not uniformly applicable to all mines. More significant are the averages for the individual geologic settings. The average disseminated ore deposit, for example, has a production of about 27,000 tons per day and uses nearly 12,000 acres of land, for a ratio of 0.44 acres per ton of daily output. The average bedded ore deposit, on the other hand, produces about 2,300 tons per day from approximately 9,200 acres for a ratio of four acres per ton of daily production. The bedded deposits use 80 percent as much land as the disseminated ore deposits while yielding only about eight percent as much production tonnage. Obviously, this is to be expected with bedded ore deposits which have much greater horizontal than vertical dimensions. Such is not the case with vein deposits, but nevertheless, their land use is greater. The mean value of output for vein deposits is 750 tons per day from nearly 4,400 acres for a ratio of nearly six acres per ton. The total land requirements for vein deposits are lower (38 percent of disseminated deposits), but the production rate is so much lower that vein deposits have the greatest land use in terms of per daily ton of output of the three major geologic settings.

When only *mineral* land is considered, disseminated deposits compare much more closely with the other geologic settings. The mineral land requirements of the average disseminated deposit is less than 40 percent as much as the average bedded deposit. When *nonmineral* land is singled out for comparison, the relative positions of each geologic setting are reversed to show bedded ore deposits using very little "nonmineral" land, while both the vein and disseminated deposits use nonmineral land moderately proportional to daily production. (See Figure 113.)

The patterns of association between output, ore land, and waste storage land follow the pattern reflected by mineral land and nonmineral land use. (See Figures 114 and 115.) Disseminated deposits and vein deposits make intensive use of ore land and utilize waste storage land in direct proportion to their volume of production. Mines on bedded deposits, on the other hand, use large amounts of ore land and very little waste storage land.

Almost two-thirds of the mines surveyed use less than 10,000 acres and almost 90 percent use less than 20,000 acres of total land. The largest mine, however, does not use the largest amount of land. It is an open pit mine using almost 12,000 acres for an efficiency ratio of about five tons of ore per day per acre used. The mine which controls the most land, almost 53,000 acres, is an underground operation producing about 40,000 tons per day. Both mines involve disseminated ore deposits.

Among the bedded deposits, the largest producer is an underground potash mine producing about 10,000 tons per day while controlling more than 16,000 acres of land. This particular property classifies 98 percent of its land as ore land and two percent as waste storage area. The bedded deposit controlling the most land, however, is a surface mine producing 4,000 tons per day from almost 22,000 acres. This mine likewise classifies 98 percent of its land as ore land and two percent as waste storage land. Both of these bedded deposits control more land than the largest mines producing from disseminated deposits. Among the properties on vein deposits surveyed, one mine has both the largest area and the largest production, using about 9,000 acres and producing 1,500 tons of ore per day.

The correlation between daily production and total land used has been calculated at 0.381, which is only slightly higher than the minimum (0.351) considered for significance with the sample obtained. Nevertheless, it is a significant correlation statistically. Larger mines do use more land than small mines, *sometimes*.

The correlation indicates, however, that the relationship is not at all precise. There is a wide range of variation in the relationship, especially among the smaller mines. As shown in Figure 111, the larger copper mines form a cluster in the over 10,000 tons per day group. It should also be noted that a large molybdenum mine falls near the center of this cluster. These mines belong to a group whose geologic setting is that of a disseminated metallic

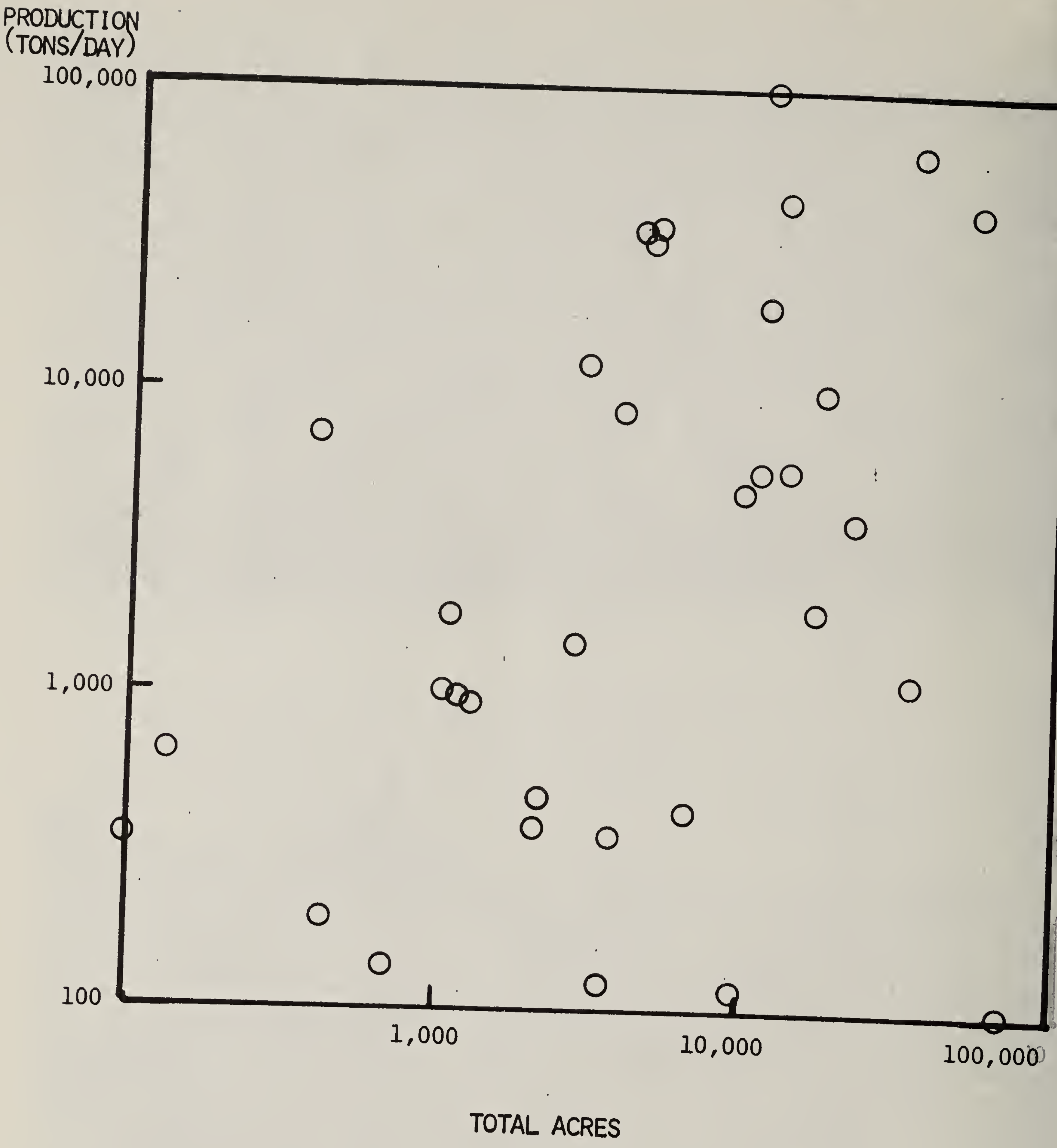


Fig. 110 - The relationship of all land held by existing nonfuel mineral producers at a particular property to the rate of production from that property is not at all consistent. For particular types of deposits, however, there are definite relationships between production rate and area used.

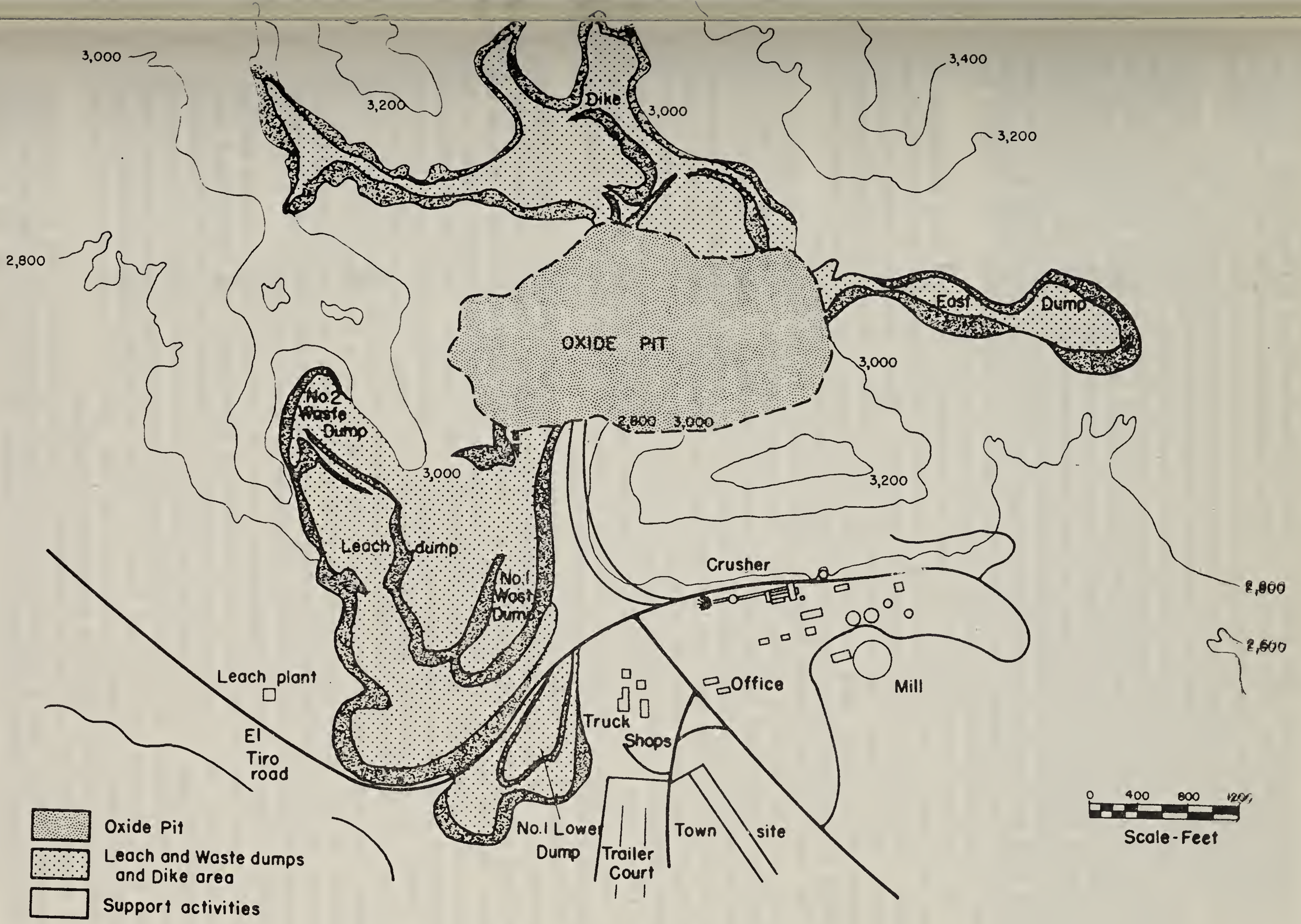


Fig. 111 - This plan of an open pit copper mining and beneficiating operation in the Southwest illustrates the various uses to which surface area must be put in the utilization of mineral resources. These include the pit itself, waste storage areas, leaching areas, beneficiation plant site, shop and office sites, access roads, and residential and commercial areas. The geology and topography of the property exert strong influences on the location and configuration of the various areas.

sulfide orebody. Nevertheless, in a general way, it may be said that mines with a larger rate of production use more land than do smaller mines, but there is considerable variation, particularly among the smaller mines. From the fact that there is a statistically significant, yet poor, correlation between volume of production and total land use, it can be inferred that there are other relevant factors, some which correlate and some which do not.

The statistical correlation of production volume with mineral land yielded correlation coefficients far below the level acceptable for statistical significance. It therefore can be inferred that there is no correlation between volume of production and extent of *mineral* land used. Similarly, there is no statistically significant correlation between rate of production and the area of land directly over the orebody. Some of the very large mines, in fact, use a relatively small amount of land directly over their orebodies. Five nonmetal mines surveyed use over 10,000 acres of ore land to support production ranging from about 1,000 tons per day to over 10,000 tons per day. The large metal mines, primarily on disseminated ore deposits, have a low percentage of ore land to total land, whereas the nonmetal mines have most of their land actually over the orebody.

The statistical correlation of the area of *nonmineral* land used with production is reasonably good, at about 0.566. There is a loose but definite association of increasing area roughly proportionate with increases in production. Where there is a strong correlation between area used and rate of production, the efficiency factor for land approaches a constant. Waste storage land use varies directly with production and has produced such a constant at about one fifth acre per ton of daily ore output for metal mines.

The most striking contrast between mines of different geologic settings comes in the percent of land which is mineral land. The disseminated ore deposits have a very low percentage of their land directly over the orebody. Generally, it is below 20 percent. The mines on bedded ore deposits (with the exception of the uranium mines) generally have more than 40 percent of their land over ore, and most are closer to 95 percent. Obviously, those producing from disseminated ore deposits require land other than actual mineral land to support production. Such requirements are often five times the area of actual mineral land used. Other types of mines take most of their land as mineral land, but not all of it is over ore. Many uranium mines have vast reserves of mineral land compared to that land which happens to lie directly over the ore zone being mined.

No justification can be found in the available data to assert that any particular mineral dominates any special land consideration or efficiency factor. Copper mines are similar in many land use characteristics, and there is a strong temptation to consider copper as the relevant variable and to give the data for copper mines an interpretation similar to the interpretation given the data for disseminated ore deposits. The two disseminated molybdenum deposits surveyed, however, exhibit land use characteristics similar to most of the copper mines, indicating that the similarities of copper mines are because of their association with disseminated sulfide orebodies, rather than because they are copper mines. A factor that does seem to be of significance in land use is the percent of recoverable mineral in the ore. Minerals such as most of the metallics need only a small percent of value per ton to be of ore quality, while most industrial minerals require that a higher percentage of the bulk mined be of recoverable mineral in order to be of ore quality.

Whether a mine is surface or underground seems to have little effect on overall land use. Open pit mines tend to be large and underground mines small, but underground block caving mines may be as large as open pit mines. The relationships that are found among mining methods seem to be a reflection of the type of ore deposit, rather than the mining method. It might seem at first that underground mines would not require as much waste storage land, because they do not have to dispose of additional waste material from stripping overburden. Apparently, this is not the case. Nearly all metal mines, both surface and underground, closely follow the established correlations.

To explain why the removal of overburden does not necessarily lead to consistently higher waste disposal land, a hypothetical case of two disseminated ore deposits of equal size but of greatly different depths may be examined. In the first, the ore is relatively shallow and the decision is to mine by open pit methods, with an arbitrary pit slope of 45 degrees. The mine's land requirements include both the pit and the waste overburden dumps. In the other case, the deposit is much deeper, resulting in a decision to use underground block caving. Since the cave will finally reach the surface and theoretically break back to the angle of subsidence, an allowance must be made at the surface for all land that may be disturbed. The angle of subsidence, estimated at 65 degrees for this example, radiates outward from the edges of the ore to encompass more land than the theoretical pit, thus tending to compensate for the overburden dump area in the open pit example. Thus, the land requirements in disseminated deposits of open pit and underground tend to be the same because the depth tends to influence the decision as to mining method, and depth combined with the angle of subsidence, in one case, tends also to compensate for the land used for storing waste overburden in the other case. Furthermore, the amount of land required for mill tailings storage would be about the same in either case.

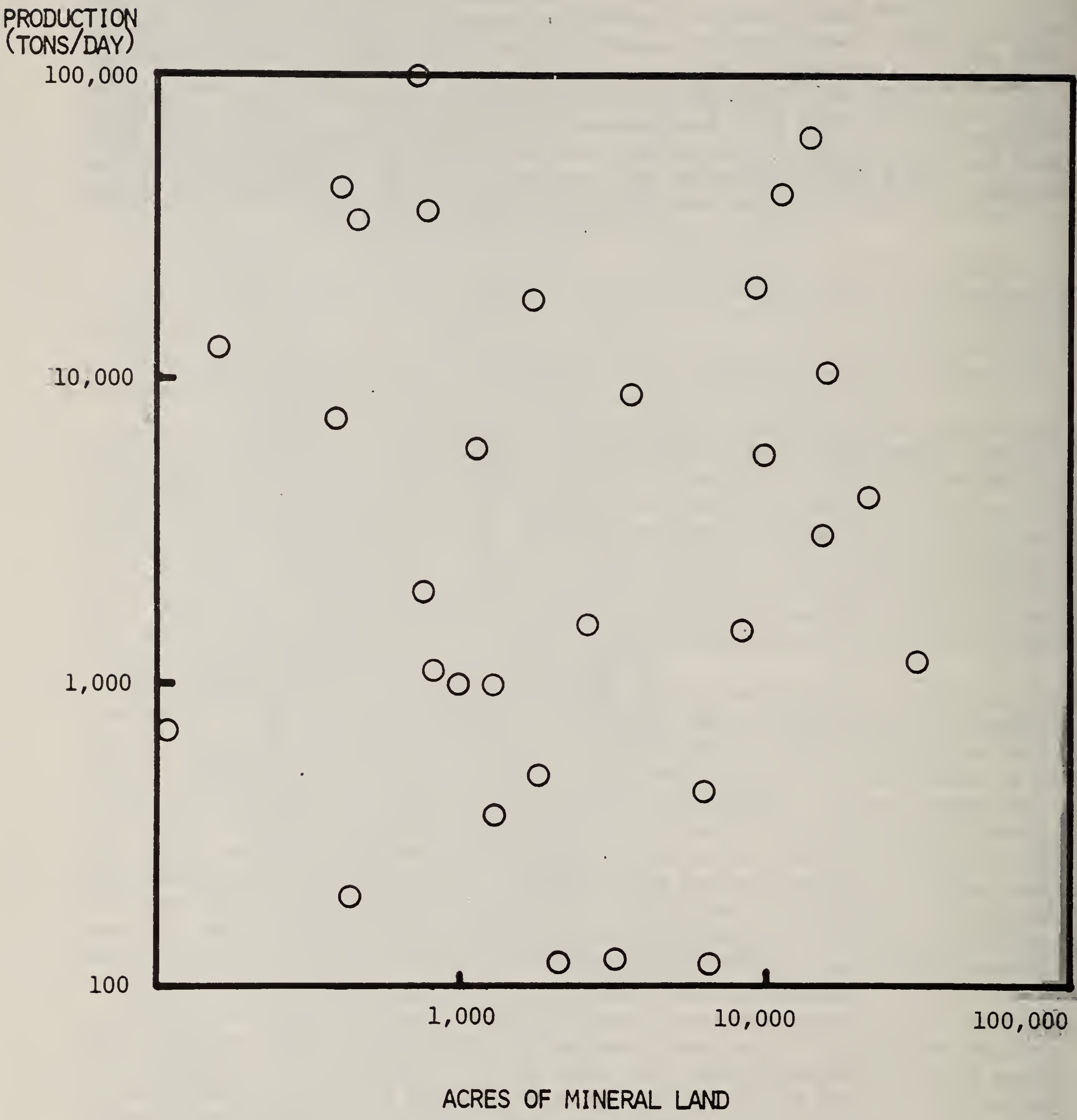


Fig. 112 - The relationship of mineral land held to volume of production has not been consistent for all types of nonfuel mining operations. Geologically similar deposits of similar size do involve similar land requirements, however.

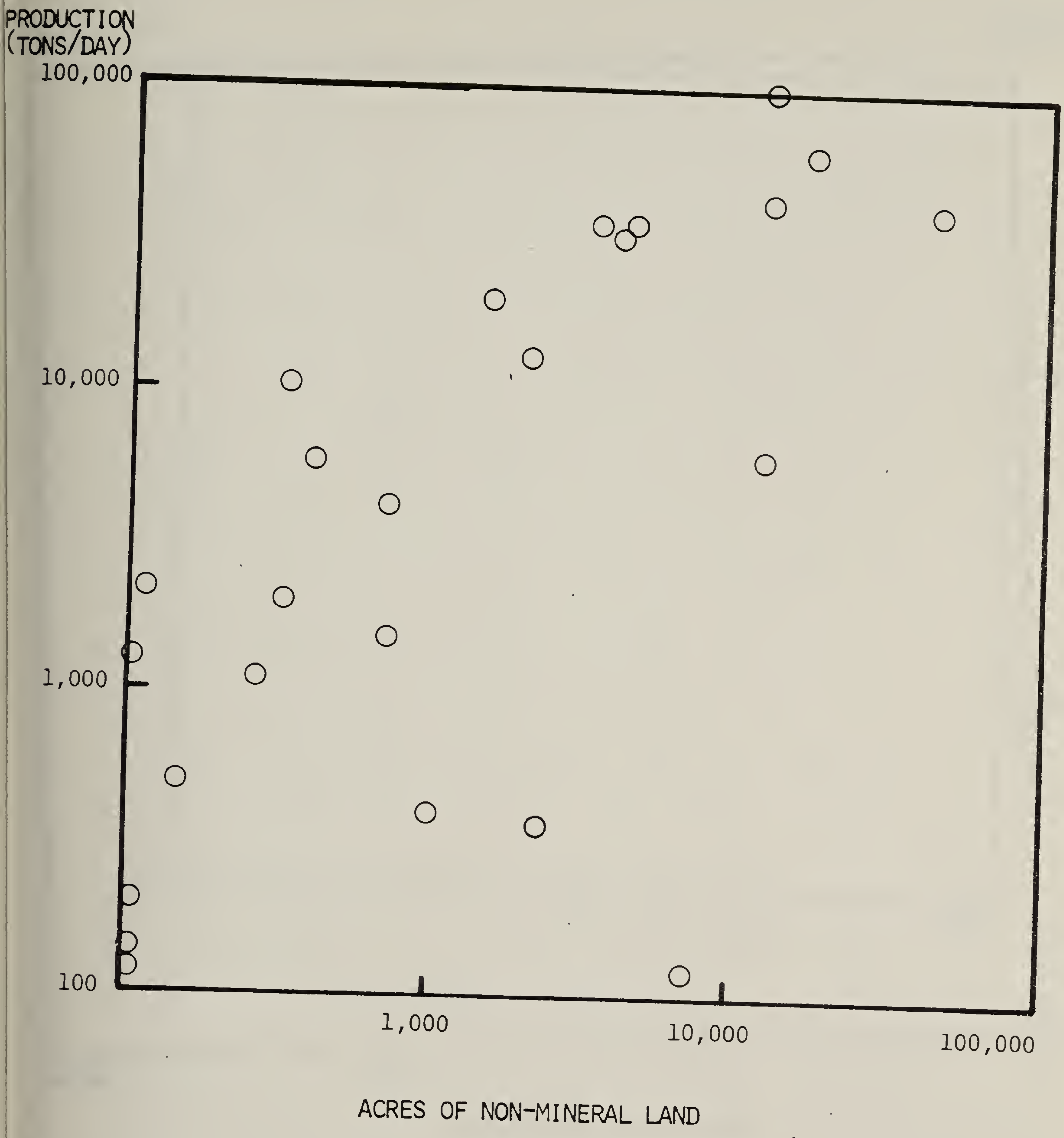


Fig. 113 - The amount of "nonmineral" land used by existing minerals producers varies somewhat with the volume of production, primarily because of the association between volume of output and waste storage requirements.

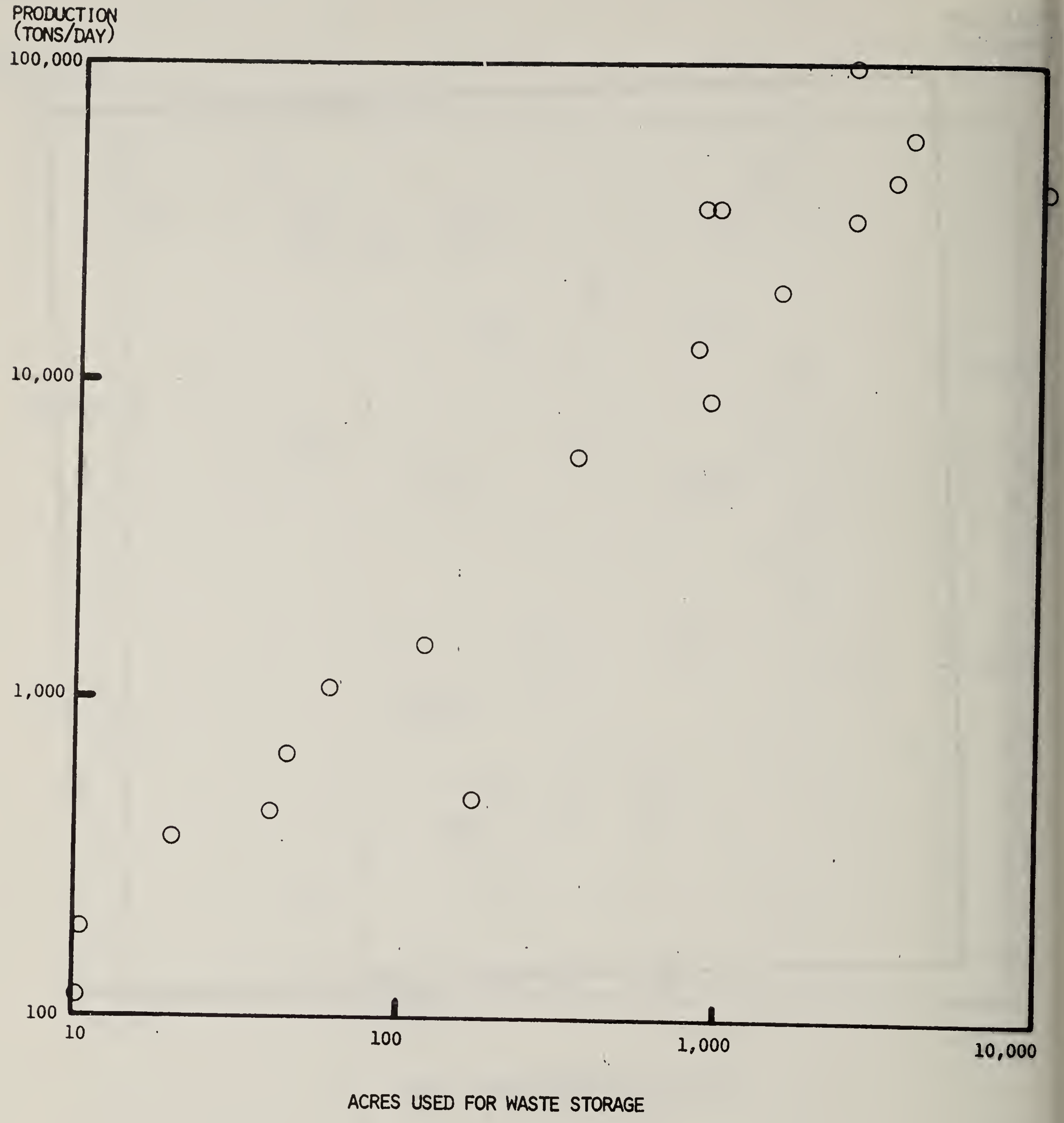


Fig. 114 - For most metal mining, there is a strong and consistent relationship between the volume of production and the amount of land used for waste storage.

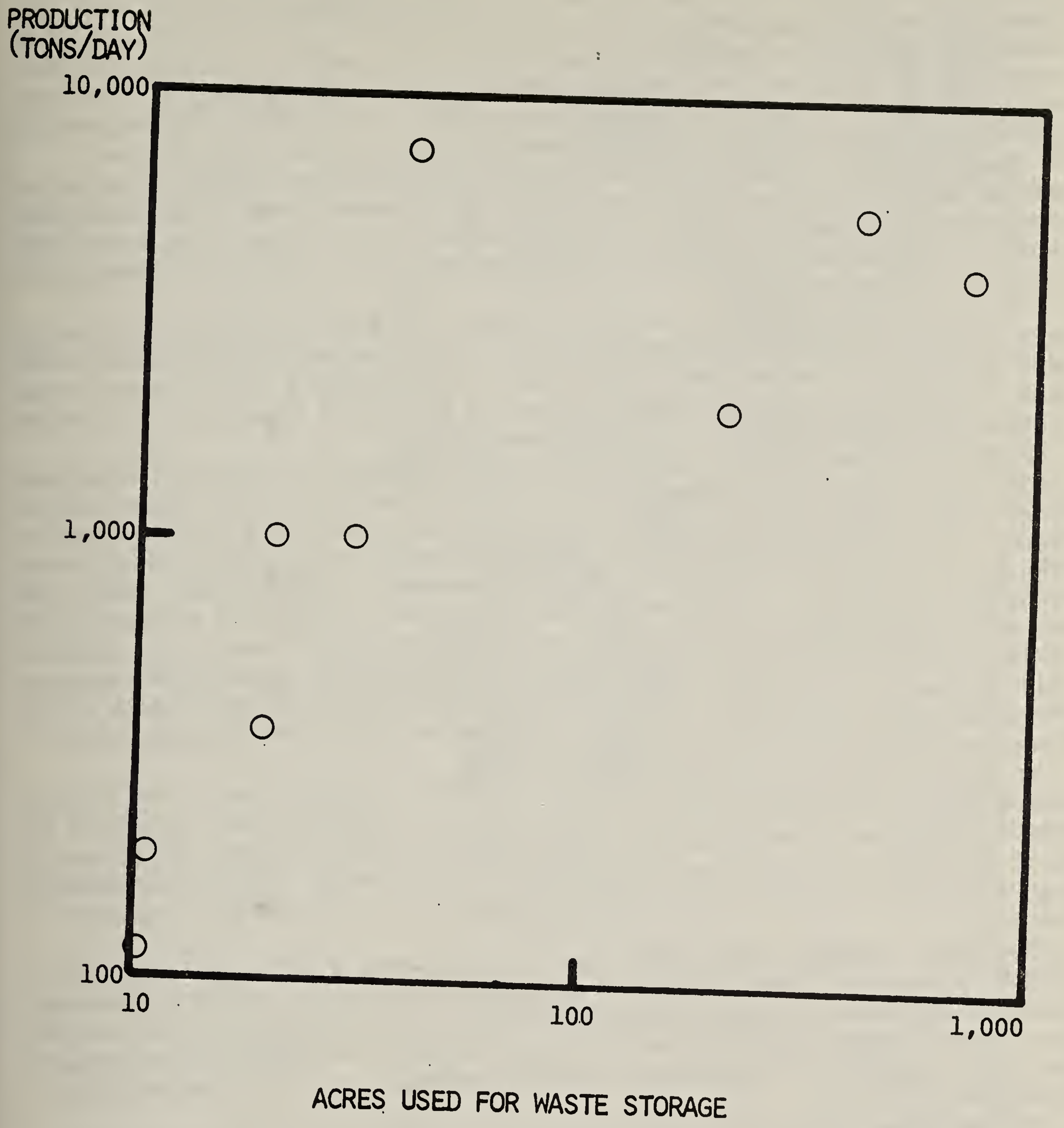


Fig. 115 - In the mining of industrial minerals, there does not appear to be any consistent relationship between the volume of output from a single deposit and the amount of land used for waste storage.

C. SOLID WASTE MANAGEMENT

Solid wastes produced in mining consist of all less-than-ore-grade rock that must be excavated in order to mine the ore. This material is often segregated into barren waste rock, containing practically no mineral value, and rock with some ore mineralization but of insufficient grade to be labeled ore under the prevailing market conditions. The latter material may be stockpiled for future processing if the price of the commodity should rise, or the valuable mineral may be extracted from its barren host rock with leach solutions or other processes less costly than the regular beneficiation and processing normally used.

Waste material is excavated in order to achieve the lowest total mining cost per unit of valuable mineral recovered. In surface mining, waste material (rock or unconsolidated overburden) overlying the ore must be removed before the ore can be mined. Barren rock may also be produced from haul road or plant site construction, although these sources of waste are relatively unimportant.

The quantity of waste rock excavated in underground mining is relatively insignificant in comparison to that produced by surface mines. Underground waste rock primarily comes from development openings (shafts, drifts, and raises), although a minor amount is also produced in stoping operations. Usually, however, it is too costly to separate ore and waste in the stopes, so that all stope production is treated as ore.

Methods of mineral recovery other than the more conventional methods of surface and underground mining include methods such as in-place leaching, solution mining, Frasch process sulfur mining, and other borehole systems such as those used in the recovery of helium. In all of these methods (even in in-place leaching where the pregnant solutions are collected and removed through a system of previously excavated shafts, drifts, and cross-cuts), the amount of solid waste from development openings is relatively small compared to the amounts of waste from conventional mining. This waste can usually be used as fill material. When boreholes are used, the resulting waste (equivalent in volume to about one and one-half times the volume of the boreholes) is negligible. Much of the cuttings or core, as the case may be, will be collected for samples. The remainder is usually dumped out on the ground near the collar of the hole.

In the open-pit mining of metalliferous deposits there is typically one to two times as much waste rock to dispose of as there is ore mined. In 1966 the waste handled at all openpit metal mines in the United States was more than one and a half times the amount of ore, or 634 million tons. The waste-to-ore ratio at selected openpit copper mines normally ranges from about one to over eight. Stripping ratios in the range of two to three are most common.

The waste overburden stripped from open pits is normally stored as near to the pit as possible. Canyons and hillsides that can be reached by a level haul make ideal disposal sites. Figure 110 shows how topography in the vicinity of an open pit was used in planning for waste dumps and leach dumps. Figure 116 shows the relative scale and placement of waste dumps, leach dumps, and tailings dams at one of the moderate size open pit copper mines in the Southwest.

Mill tailings are normally transported from the beneficiation plant that produces them by gravity through a launder to storage in one or two tailings ponds. The tailings dams are originally built up with material from borrow pits or other sources using various combinations of draglines, trucks and scrapers. Present systems of dam building pass a portion of the tailings through cyclones placed against the dam area. Sand produced from the cyclones is allowed to build up in piles and dry. Then a dozer pushes and compacts sand on top of the dam, building it up as needed.

In strip mining methods, advance stripping waste is stacked in the portion of the pit from which the ore was last mined. When a new portion of the ore zone is exposed, it is mined first and then filled as another cycle of production commences. In this method of mining, which is especially well adapted to the mining of relatively thin, flat-lying, tabular ore zones, the only waste that requires disposal outside of the mined area is the overburden from the initial cut in a block. Sometimes this waste is used to fill the last cut in a given

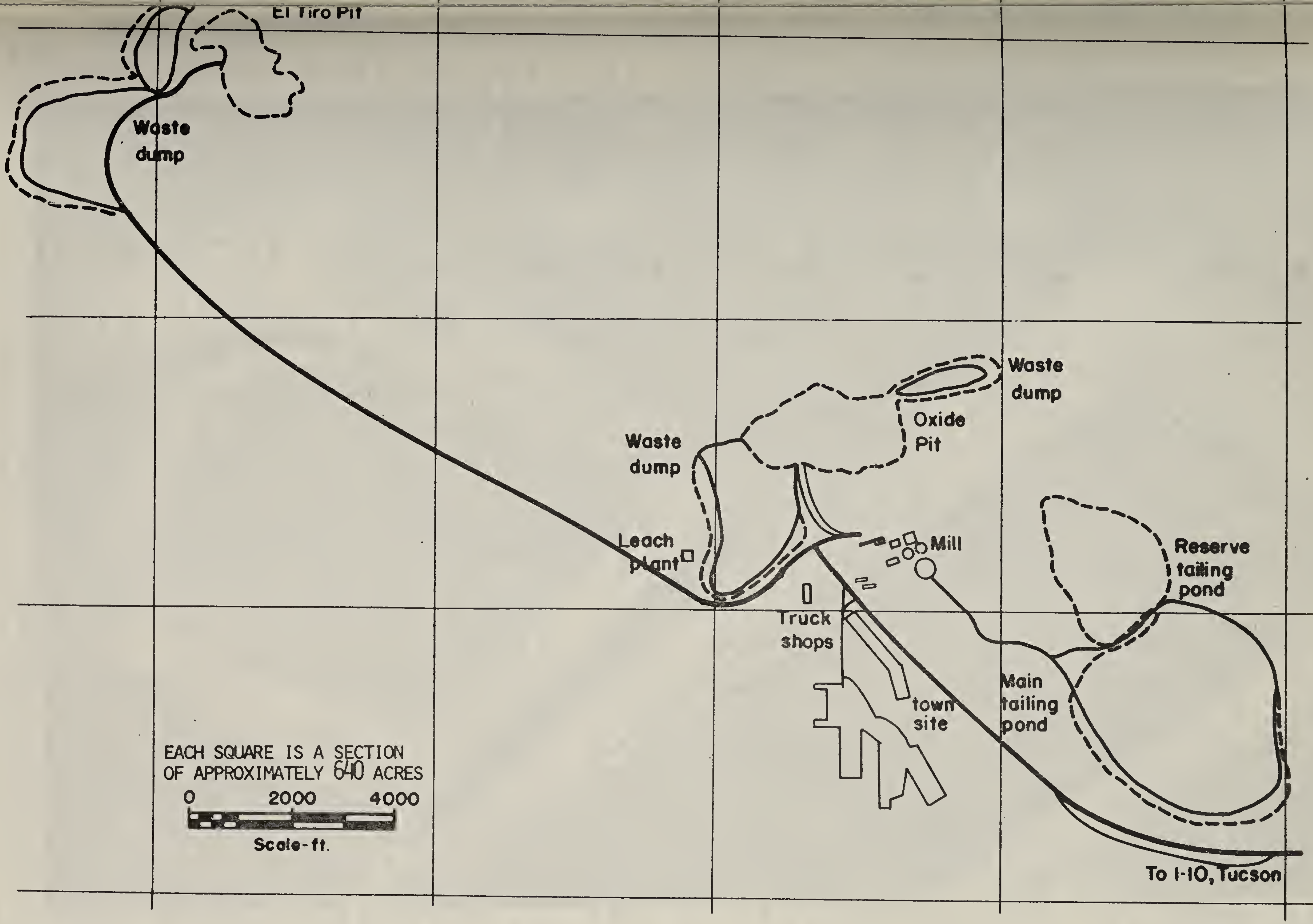


Fig. 116 - Waste storage and other auxiliary land uses form a significant part of the total land requirements involved in present-day mineral resource utilization. Many times the same surface area will serve multiple uses, with plants, shops, offices, and residences built on top of waste storage areas that are no longer active.

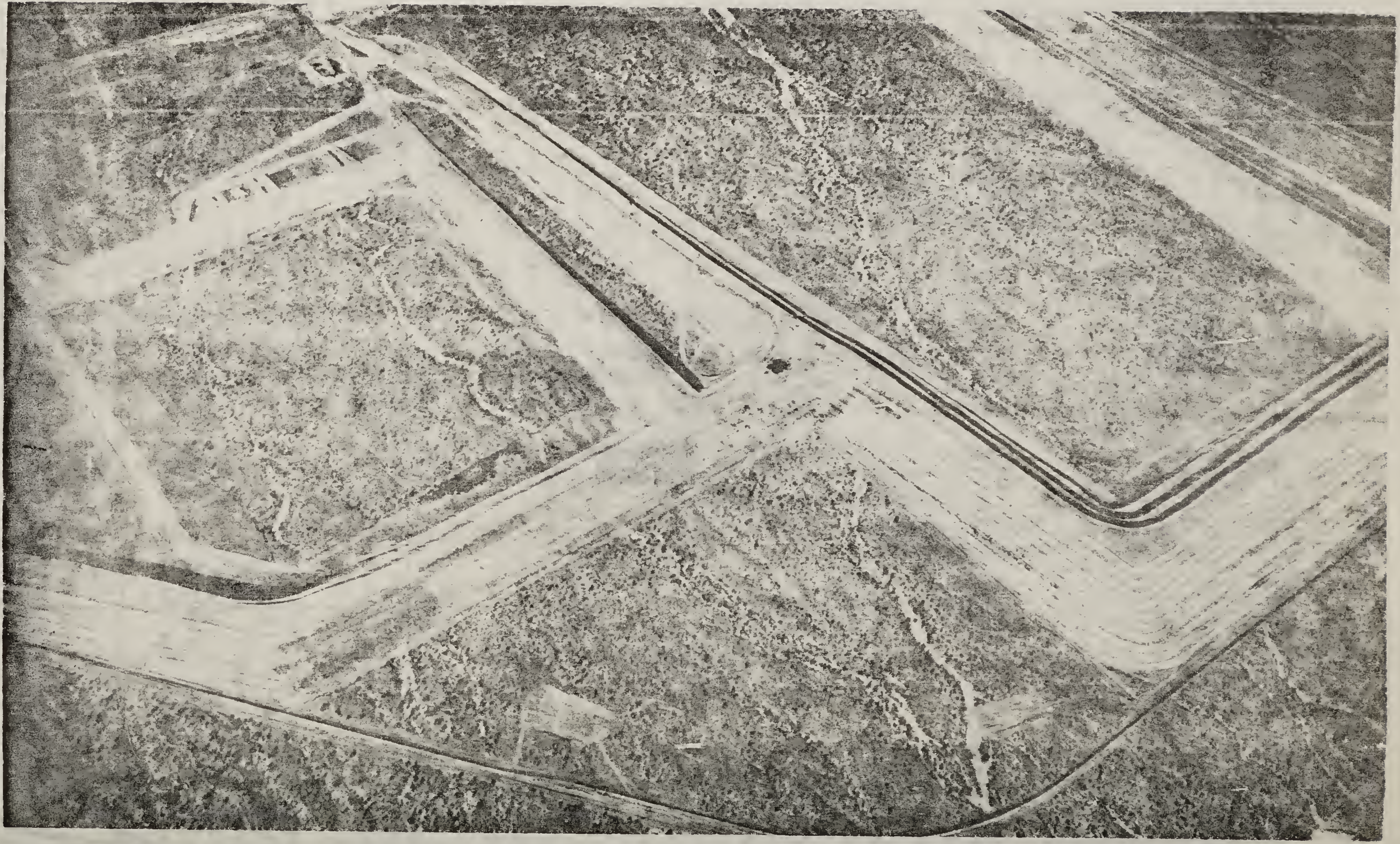


Fig. 117 - The initial development of orebodies for surface mining frequently requires the utilization of substantial surface areas for the disposition of overburden and for the construction of areas for the storage of waste materials

deposit or block if the haul distance is not excessive. Because of the expansion or swell of the excavated material, the surface of the spoil is higher in elevation than the original ground surface. The surface resulting from a dragline casting operation is typically a series of parallel ridges and valleys.

The quantity of waste rock produced in underground mining is extremely small in comparison to the quantity generated in surface mines. While the amount of waste rock moved in underground mining is relatively small, the handling cost per ton for underground waste is far greater than for surface waste. Although in some mining methods, waste rock is used underground for stope fill, this material is normally transported to the surface for disposal. Most waste rock is excavated underground during the extension of development openings such as shafts, drifts, and raises, with a minor amount coming from stope operations.

In deep ore deposits in weak country rock, one of the supported stope mining methods (cut-and-fill or square-set stoping) is frequently used. Both of these methods use waste material for stope fill to provide permanent ground support, which in turn permits safe mining. With these methods, the mine operator is thus able to dispose of some of his waste products underground. The fill material must be inexpensive, readily available, and easy to deposit in the stopes. It must also provide an acceptable working surface and be capable of providing adequate support. Mill tailings possess all of these qualities and are the most popular type of underground fill material. Development waste rock is occasionally used in this manner, but it is seldom available in sufficient quantity to satisfy total requirements. Occasionally, the supply of mill tailings will also be inadequate, so that material must be mined either on the surface or underground specifically for the stope fill. These situations are rare, however, as there generally is a surplus of waste to dispose of from the mining and concentrating operations. Stope filling is an expensive operation, so that it is used only when permanent rock support is required for safe mining. Because of the stope fill cycle, cut-and-fill mining and square-set stoping are two of the costliest underground mining methods.

As is also common in surface mining, waste rock from underground operations is often used in constructing dams for concentrator tailings. Again, however, the small amount of waste rock produced from underground mining is usually insufficient and must be supplemented with material from other sources.

There are noteworthy differences in the practices of waste disposal or storage between small and large scale mining operations. As a generalization, small-scale operations tend to have higher operating costs and are forced to mine higher-grade material. They accomplish this by using a higher cut-off point and a lower stripping ratio, by *high-grading* or *gophering* (mining only the rich portions of a deposit without regard to the subsequent recovery of lower-grade portions), by selective mining (which may include sorting waste from the ore in stopes), and other similar practices, all of which tend to sacrifice recovery for the purpose of minimizing the amount of material to be handled. This results, of course, in much less solid waste to be disposed of per unit of *value* recovered than in the larger scale operation, which may take much more waste in order to effect a high recovery and good conservation of a mineral resource.

Little attention is usually given to the disposal of solid wastes in remote areas. They are usually placed in the most convenient spot and nothing further is done to stabilize or treat such rock dumps and tailings ponds. In time, weathering produces soil dumps naturally, if the region supports vegetation. In more barren and mountainous terrain, mine dumps on steep hillsides tend to blend in with the natural scenery and often are mistaken for natural talus slopes.

In mountainous or rugged terrain, mine waste dumps may afford the only level ground in the near vicinity of the mine. In these circumstances mining companies normally utilize the level surface of the dumps for many purposes. The Morenci Branch of Phelps Dodge Corporation at Morenci, Arizona, has used mine dumps as a site for the construction of much of its needed surface plant, including office buildings, garages, shops, warehouses, and storage yards. Most of the company housing for employees at Morenci is also built on waste

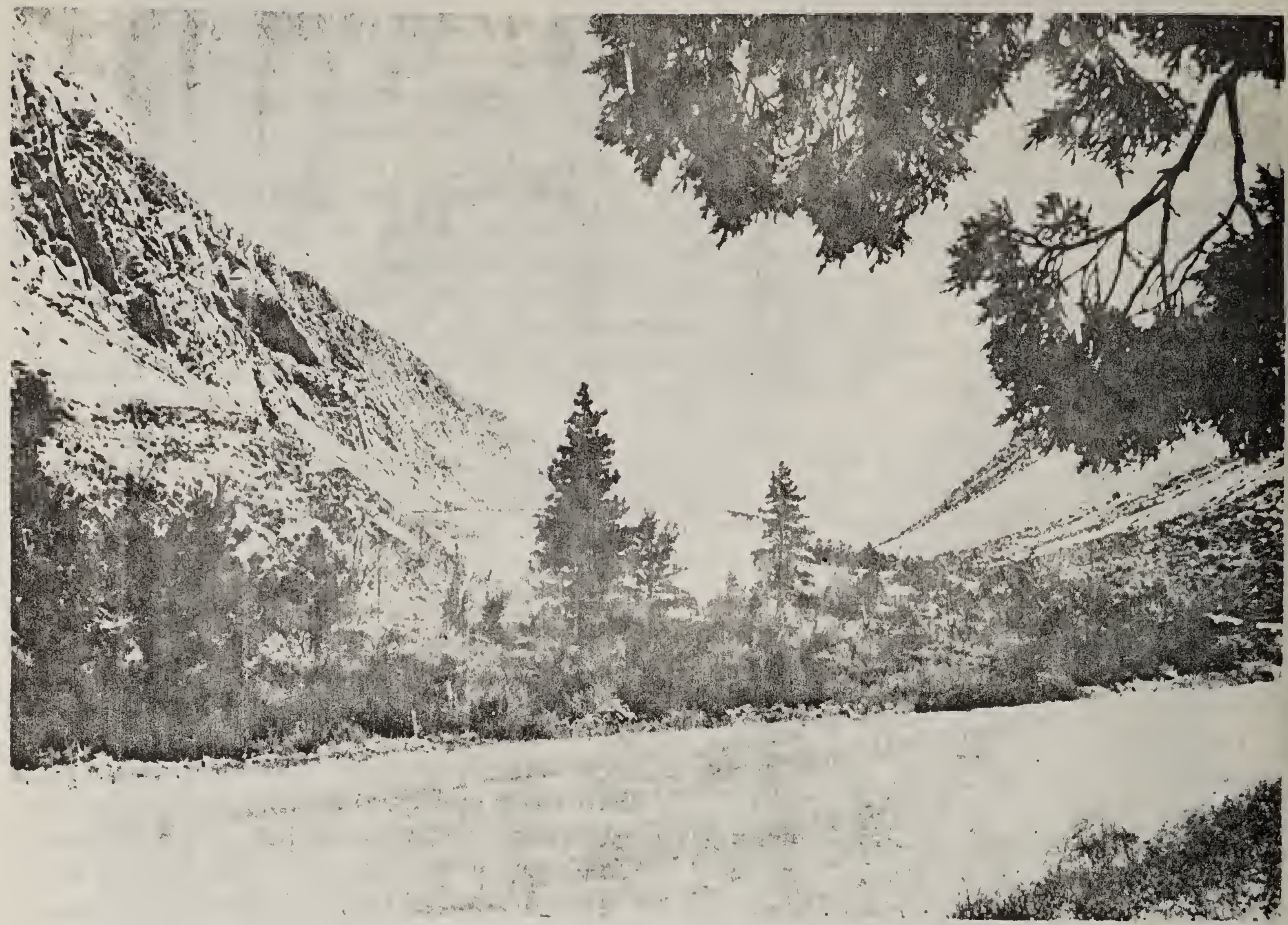


Fig. 118 - Tailings disposal ponds of the Union Carbide Corporation's tungsten mining operation northwest of Bishop, California, on the eastern slope of the Sierra Nevada. The tailings dams are covered with vegetation that blends with the environment. The lower pond was described by one impartial observer (a five-year old boy) as a "nice little mountain lake."

dumps. Thus, under certain circumstances, waste storage areas have attained far greater usefulness and value than the original natural terrain.

Most of the metals, with few exceptions, are mined by conventional mining methods and solid waste is disposed of (stored) in accordance with the mining and beneficiation systems used. A relatively small (but growing) amount of copper is mined by in-place leaching, and the solution mining of uranium is still being conducted mostly on an experimental basis. Native sulfur deposits mined by the Frasch process are the major source of the nation's sulfur supply. As mined, this material is normally 99.5 percent pure and there are no solid wastes to dispose of or store. Helium is recovered through boreholes as a gas and there are no solid wastes except the negligible amount of cuttings created in the drilling of the borehole.

Uranium mill wastes are usually given special attention in their disposal. Uranium ores in the Western United States normally contain from 0.20 to 0.25 percent uranium oxide (U_3O_8), and the radioactive materials present are the normally occurring U^{238} and U^{235} isotopes with their decay products. Approximately 70 percent of the radioactivity in the ore remains undissolved in the solid mill tailings, which must then be impounded within tailings dams. The materials in the dams are usually stabilized by various methods such as leveling, covering with soil or riprap, and (where practical) planting with vegetation. In Colorado, proposals have even been presented to the state for stabilizing the tailings pits at all abandoned uranium mill sites.[74] At Rifle, Colorado, the Union Carbide Corporation leveled the top of a 10-acre tailings dump and then riprapped the sides with broken pieces of concrete from an old mill foundation, subsequently covering the riprap with six inches of dirt. This surface was then planted with seed of various grasses and sprinkled during the initial growing season to help the grasses get established. In more arid areas, however, the company does not deliberately plant vegetation on old tailings storage areas but does cover them with a mixture of rock and soil.[75]

Most of the industrial minerals are mined by conventional methods and the solid wastes produced are disposed of (stored) in accordance with the mining practice used. Industrial minerals, however, tend to have a lower unit value than most metallic ores, and hence will not support a high recovery cost such as results from deep underground mining and surface mining with high stripping ratios. The amount of waste to be disposed of from the mining of industrial minerals is thus usually much smaller than that which accrues from the mining of metalliferous deposits.

Most sand and gravel deposits that are mined are right at the surface so there usually is no waste overburden to store. Cleaning and sizing of the excavated material usually produce little or no solid waste, and abandoned portions of the pit itself provide more than ample disposal sites for what waste is created. In the mining of limestone rock for the manufacture of cement, economics dictate that the rock must be mined very near the cement plant. Deposits selected for mining are usually right at or very near the surface, and the minor amounts of overburden are frequently blended into the raw materials used in cement production. Thus, waste created from the mining of cement rock is similarly not of much consequence. Industrial materials (such as soluble salts, including those of sodium and potassium) used in the chemical industries are mined by borehole and solution methods. These mining methods produce virtually no solid wastes.

Fig. 119 - Tailings dump of the Union Carbide Corporation's processing plant on the Colorado River at Rifle, Colorado. Tailings berms have been planted with grass which is watered frequently to maintain its growth in the normally semi-arid environment.

Table 24

COMPARATIVE SOLID WASTE PRODUCTION FOR UNDERGROUND AND SURFACE COPPER MINES

	Open Pit Mine	Large Underground Mine (block caving)	Small Underground Mine (square set stoping)
Grade of ore			
(1) in percent copper	.75	.75	4.0
(2) in pounds of copper per ton of ore	15	15	80
Material mined per day			
(1) tons of ore	40,000	40,000	2,500
(2) tons of waste[a]	100,000	3,200	200
Tons of concentrator tailings per day	39,000	39,000	2,167
Total tons per day of waste material produced	139,000	71,000	2,367
Average tons per day of copper produced[b]	300	300	100

[a] Assumes a 2.5:1 stripping ratio for the open pit mine, and waste rock production at eight percent of ore production for the underground mines.

[b] Assumes a concentrate grade of 30 percent copper and a recovery rate of 100 percent. Actual recoveries are usually less than 100 percent.

Source of data: U.S. Bureau of Mines, *Minerals Yearbook, 1966.*

FOOTNOTES

74/ R.G. Beverly, "Unique Disposal Methods are Required for Uranium Mill Waste," *Mining Engineering,* (June 1968), pp. 52-56.

75/ R.G. Beverly, *Uranium Waste Disposal,* New York: The Union Carbide Corporation, as cited in the *Engineering and Mining Journal* (April 1968), p. 96.

CHAPTER 14

MINERAL AND OTHER USE OF THE PUBLIC LANDS

Has the utilization of mineral resources on the public lands had any measurable effects upon other uses of those lands? Have nonmineral uses of the public lands had any measurable effects upon mineral resource use?

A. MULTIPLE AND COMPARATIVE LAND USE

1. Dimensions of Multiple Use

Within the last two decades, the term *multiple use* has come into considerable prominence with respect to the public lands of the United States. It has been widely accepted as a prime objective of public lands management. In fact, it has been so established by legislation accompanied by the actual practice and policies adopted by federal agencies as well as by numerous private and non-federal public agencies concerned with the use of the land. The term *multiple use* has a nice ring to it and a connotation of efficiency and a greater good for a greater number of people. It implies a use of resources that is better than normal, or at least better than the past use of the nation's limited natural resources.

Although the term *multiple use* may be relatively new, the concept in fact has existed for generations, if not for centuries. At face value, the term or concept *multiple use* refers to the use of a given amount of land for more than one purpose. If this is accepted as an accurate definition of the multiple use concept, then two aspects of this definition must be examined. The first concerns the *amount of land* involved. The second involves the specific *purpose* involved in the use of that land.

An *amount* of land, be it public or private, has at least four dimensions that are of relevance to the term and concept of multiple use. Nevertheless, when the term is commonly used, most persons think only in terms of one of the aspects of an amount of land, its *surface area*. The surface area of land is a variable and may range from relevant areas as small as one square foot up to areas as large as thousands of square miles. The size of the particular area concerned is of vital importance to the meaning for the term *multiple use*. In general, it may be said that the smaller the area, the less the possibility of it serving more than one purpose at any one time. On the other hand, the larger the area involved, the greater the chance that it may be used for more than one purpose at any one time. Obviously, the square foot of ground that is occupied by a tree cannot readily be used for any other purpose as long as that tree is there; however, a forest covering 1,000 square miles can be used for many things besides the growing of trees. This same general principle applies to other potential and actual uses of any area of land.

The second critical dimension of an amount of land that is relevant to the multiple use concept is *time*. In general, the shorter the time period involved, the less the possibility that a given amount of land may be used for more than one purpose. On the other hand, the longer the period of time involved, the greater the possibility that any one amount of land would be used for more than one purpose. The square foot upon which a tree grows can be used only for the growing of that tree during the life of that tree. Nevertheless, over a period of several hundred years, that same square foot may be used for more than the growing of one tree, unless, of course, the tree happens to be as long-lived as the Redwoods or the Bristlecone Pine. More relevant to mineral resource use, the several hundred acres occupied by a mining operation that lasts for five, 10, or 20 years may allow only one purpose of the land during that life of the mine. Over a period greater than that, however, the land may be used for more than one purpose. In fact, over a period of 100 years or more, it may be used for several purposes. This has been true throughout the Western United States.

One of the most prominent examples of multiple land use over time is found in Central California, where intensive mineral development on the public lands of the West began in the 1840's. Much of the area around Sacramento was used originally for placer mining operations. When the placer deposits were worked out, the fields of dredger tailings were planted with orchards and citrus groves. As urbanization spread throughout the Sacramento area, citrus groves were removed and replaced with housing developments and commercial and industrial building sites. Thus, over a period of a little less than 120 years, this same amount of land saw three distinct uses–mineral, agricultural, and residential. Even between the time the early mining operations were abandoned and the dredger tailings fields were graded and planted to citrus groves, however, the mining areas formed a habitat for wildlife. As a result, a fourth use (that may be termed non-deliberate) of the land has also occurred in this particular area over the past 120 years. Similar examples of changing patterns of use of the land are common throughout the West.

The third major dimension that an amount of land may have is *depth*. Normally, when speaking of the land, it is the surface of the earth that is considered. Legal definitions of land, however, consider the volume that extends all the way to the center of the earth, and in many cases, even include air space above the surface. With regard to mineral activity on the land, the depth dimension is a critical one, because for many mineral industry activities it is possible to have one use of the land at depth and another use of the land at the surface at the same time. This is particularly true with some of the newer techniques of solution mining (where subsidence is not a problem), and it has always been true to great extent where underground mining methods (other than caving techniques) have been used. There exists, for example, a relatively large salt mine under the city of Detroit, and throughout the nation similar situations exist where mineral industry activity is carried on at depth while the surface of the land is used for other purposes. Of course, where open pit mining or other surface operations are used, the depth and the surface become one, and multiple land use *at any one time* for a specific small area is difficult to achieve.

A fourth critical dimension of the land is its composition. To many, the land consists only of the minerals, the rocks, the soil, and the surface of the earth, or those components that go to make up the earth's crust. To others, however, land includes the water resources and the vegetation that grows on the crust of the earth. To many, it also includes the wildlife that lives on the surface. Under some concepts of land, particularly in economics, all natural resources–animal, vegetable, and mineral–are included.

The other portion of the definition of the term *multiple use* involves the purpose for which the land may be utilized. Like the first part, this portion of the concept is also subject to several definitions or dimensions. Obviously, the extraction or removal of its minerals resources is one use to which the land may be put. The extraction and use of water may be another purpose in the use of the land. The growing of trees for watershed management, for shade, or for commercial lumbering operations is also another purpose for which the land is used, particularly in the Western United States. The land may also be used for growing things other than trees. It may be used to provide feed for cattle. It may also be used for other agricultural purposes, to grow fruit trees or field crops. The land may also be used for recreational purposes of a wide variety. It may be used to provide a habitat for fish and game, providing recreation for those who would hunt or fish. The land may be used to provide a scenic attraction for campers or other tourists who wish to use the land as a place of visitation. The land may also be used for residential purposes, as a place upon which homes may be built and people may live. The land may also be used for commercial and industrial activities. In fact, the land may be used as a site for every conceivable activity of man.

It is quite often assumed that these varying uses of the land are either incompatible or simply cannot be carried out on the same land at the same time. In truth, just the opposite is true. *In fact, most land uses are not only compatible but tend to enhance each other.* Multiple uses of the land are not necessarily mutually exclusive. In many cases, a single activity may serve many purposes. For example, the growing of trees on a given surface area with a maintenance of grass between those trees may serve recreational purposes, grazing

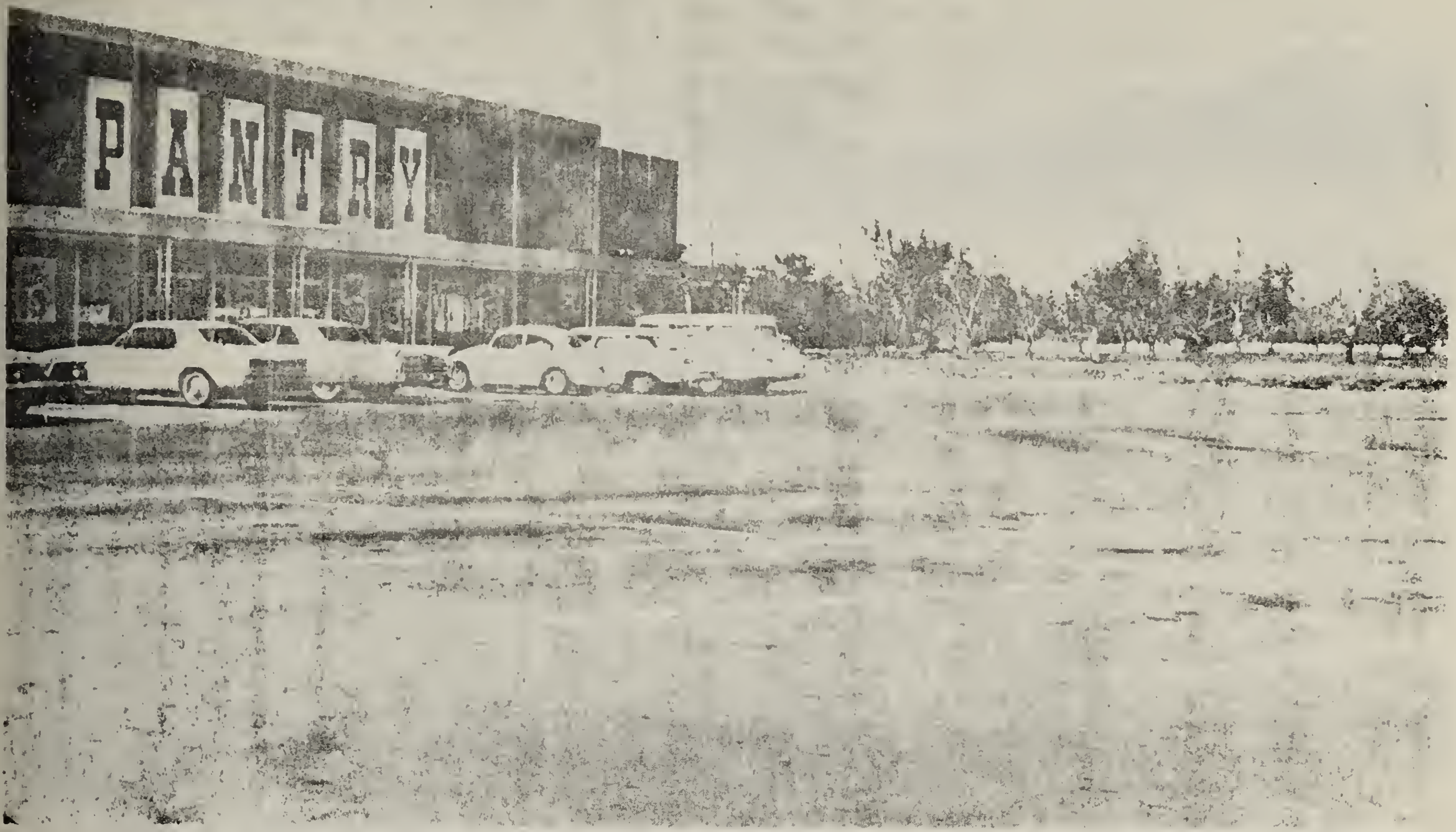


Fig. 120 - Suburban shopping center just east of Sacramento California, built on land cleared of citrus trees which had been planted on dredger tailings left from former gold mining operations along the American River. Some orange trees still growing in dredger tailings are visible at right. Over the last 100 years, this same land has thus served three distinct uses—mineral, agricultural, and urban.

purposes, forestry purposes, and in some cases, it may also serve residential purposes. The range of uses, of course, is subject to the size of the particular area involved.

More relevant to this discussion is the fact that the mining of gems or particular types of rock by amateurs known as *rockhounds* (although strictly speaking a utilization of mineral resources) is usually considered by those performing this activity as a recreational use of the land. Such is the case in many areas throughout the Western United States. Similarly, commercial mining activity itself is a widely utilized tourist attraction and has thus become a recreational use of the land. The old ghost towns scattered throughout the West are perhaps the most prominent examples of this. In addition, modern mining operations also serve as tourist attractions in many locales, particularly where these operations are relatively unique, such as at Bingham Canyon near Salt Lake City. The *multiple purpose* to which a *single activity* on the land may be put is, of course, not restricted to mineral activity and recreation, although recreation is perhaps the broadest of all the categories involved in the use of the public lands.

2. Comparative Land Use in Arizona

A study of the extent of surface area occupied by various land uses in Arizona indicates that the mineral industries use a relatively small amount of surface area compared to other activities. With a substantial portion of the West's mineral production coming from Arizona, it is likely that mineral resource utilization requires even less land in the other Western States. This is supported by the fact that more waste material (247.4 million tons in 1966) has been handled by surface and underground mines in Arizona in recent years than in any

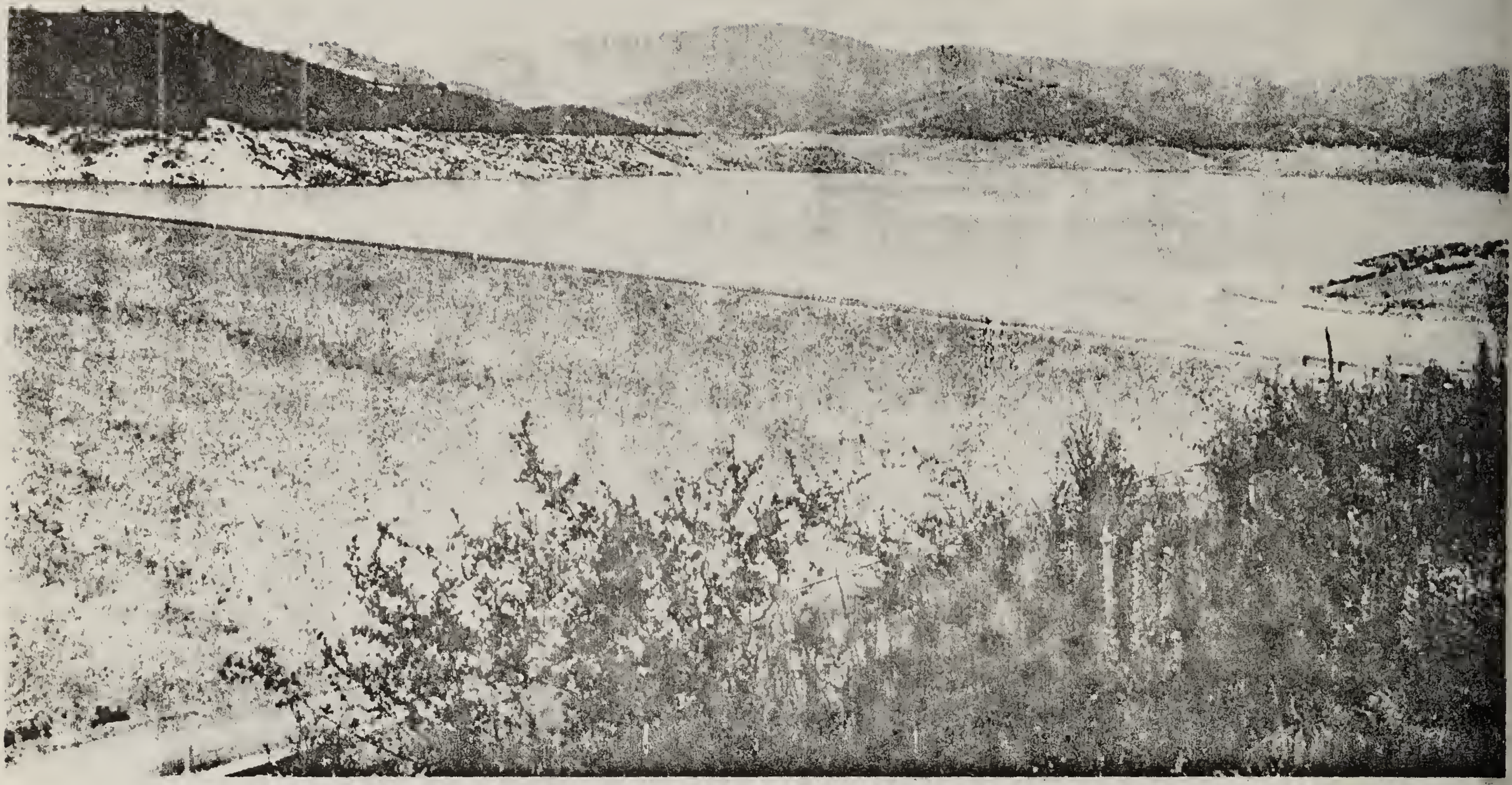


Fig. 121 - Multiple use is a concept applicable to the materials moved by mining operations as well as to the surface area involved. Construction of the Oroville Dam in California was facilitated by the extensive use of dredger tailings available nearby. The waste product of previous mining thus enabled the creation of a lake for recreational purposes, the provision of water for urban and agricultural activities, and the production of electric power.

other state in the nation. The only other Western State with substantial waste output has been Utah, with about one-third as much waste material mined as Arizona.[76] With a rather definite relationship existing between amount of land used and volume of waste material handled (see Chapter 13), Arizona mineral industry activities undoubtedly occupy more land than such activities elsewhere in the West.

In 1966, Arizona's mineral industries occupied approximately 93,000 acres, only 0.13 percent of the entire area of the state (see Table 25). Mineral industry activity in other Western States undoubtedly involves the use of considerably smaller areas. Despite the relatively small amount of land used, the industry produced mineral commodities worth almost $622.1 million.[77] This is equivalent to a gross annual output of approximately $6,700 in minerals from each acre of ground used by the industry. Only manufacturing and commercial uses of the land yield a higher gross revenue per acre. It should be remembered, however, that this $6,700 per acre per year figure is an average, and as such is probably not applicable to all types of mining activity. Some types of mineral resource use undoubtedly yield more per acre, while others produce less.

Despite mining's major importance in the economy of Arizona, it is far from being a major user of land. In recent years, grazing has been the largest user of Arizona land, with such activities occupying over 40 million acres, more than 55 percent of the state's total area. This large amount is somewhat deceptive, however, for many areas of the state are suitable for little else other than grazing. As a result, the state's grazing acreage is in effect a residual, with such activity occupying the land remaining after all other uses have been accommodated.

The large acreage devoted to grazing in Arizona is only partly reflected in the value of the state's livestock output. In 1966, cash receipts received by Arizona ranchers and feeders for the sale of livestock and animal products amounted to $245.5 million.[78] This amounts to an average annual gross output from grazing land of about $6 per acre. The per-acre figure is deceptively high, however, since a substantial portion of the value of livestock output in the state is realized from sales from feedlots, not from open range or pasture. Thus, the actual gross yield from grazing land in Arizona is probably much less than one percent of the gross annual yield of mining land.

The second largest user (perhaps *occupier* is more appropriate) of land in Arizona is recreation. This category actually involves a multitude of activities, however, and thus should probably be separated into several classifications. As estimated by the Arizona Outdoor Recreation Coordinating Commission, the largest class of recreational land use involves some 15 million acres termed *natural environmental areas.* Another four million acres in the state are in *wilderness areas,* and an additional one million acres are in what the Commission called *scenic splendor areas.* This relatively low density recreation thus occupies a total of approximately 20 million acres of Arizona land.[79]

The economic return from low density recreational use is difficult to measure, and such measurement may not even be appropriate. In 1965, however, a study of the economic impact of hunting and fishing in Arizona estimated that those using the land for hunting made expenditures of about $21.4 million.[80] Considering that the 15 million acres categorized as *natural environment* was used primarily for hunting, then the gross annual yield from this recreational use was less than $1.50 per acre. Measurement or even reasonable estimation of the average gross annual output of land used for other recreational purposes, as outlined in Table 25, is virtually impossible.

Commercial forestry is also a substantial user of the land in Arizona, but the total area devoted to such use ranks far behind grazing and recreation. In 1966, the state had an estimated 3.9 million acres in commercial forest use, including large areas under the jurisdiction of the United States Forest Service. From this acreage, a total output of lumber and forest products valued at more than $33.5 million was obtained in 1966.[81] This represents an average annual gross yield of about $9 per acre, somewhat higher than the yield from grazing.

Close behind commercial forestry as a user of land in Arizona is national defense. Military installations and other Department of Defense facilities controlled more than 3.1 million acres of Arizona land in 1966. The economic yield from such use of the land is diffucult to ascertain. Certainly, such activities provide income to the state, but such a yield is not consistently related to the amount of land involved.

Crop agriculture is the only other major activity in Arizona using more than a million acres. In 1966, crop raising occupied about 1.25 million acres in the state. From this land, a total output valued at approximately $259.9 million was produced.[82] This represents an average annual yield of a little over $200 per acre. Again, it should be remembered that this is an average and is not uniformly applicable to all agricultural lands.

A variety of other uses occupy more land than the mineral industries in Arizona. Even though the state is semi-arid, and much of it considered desert, the surface area of lakes and running streams amounts to more than four times the area involved in mineral resource utilization. A similar amount of land (more than 370,000 acres) is covered by rural roads and highways. An additional 49,000 acres are covered by roads in the state's many National Parks, Monuments, and Forests. Urban uses, mostly residential sites, occupy another 320,000 acres of Arizona land.

The only significant land uses that occupy less space in Arizona are the railroads and gas and electric utilities. Railways in the state cover about 54,000 acres, while public utility lines (including both high tension transmission lines and gas pipelines) use about 60,000 acres of Arizona land. If transmission lines of less than 22,000 volts are included, the rights-of-way for electrical power lines alone occupy more land than the state's mineral industries. The economic yield from these other uses of the land are almost impossible to determine and in any event are not usually related simply to the size of the area involved.

Although the economic return from land utilization is not measurable in a number of instances, the comparative use of the land in Arizona indicates that *in economic terms, mineral resource utilization is the highest use of the land* outside of urban areas. Most other uses, except some commercial and industrial uses, yield less than five percent of the annual gross income per acre obtained by mining.

Table 25

COMPARATIVE LAND USE IN ARIZONA, 1966

Primary Use	Estimated Area (Acres)	Percent Of Total
Grazing (Minimum)	40,039,000	55.08
Recreation	23,092,000	31.76
High Density Recreation Areas	92,000	
General Recreation	3,000,000	
Natural Environment, Scenic Splendor, and Wilderness Areas	20,000,000	
Commercial Forestry	3,870,000	5.32
Military	3,134,000	4.32
Crop Agriculture	1,250,000	1.72
Water Surface Area	384,000	0.52
Inter-city Roads and Highways (Does *not* include 49,000 acres of roads in national forests and parks)	373,000	0.51
Urban (Residential, commercial, and industrial)	320,000	0.44
Mineral Industries	93,000	0.13
Public Utilities	60,000	0.09
Railroads	54,000	0.08
Burned-over Areas (1967 Only) (47,000 acres burned over in 1966)	19,000	0.03

Source of data: Division of Economic and Business Research, The University of Arizona, and various other sources.

B. RIGHTS OF PUBLIC LAND USE

1. Federal Agency Jurisdiction

Most of the known mineral resources of the public lands are located in areas administered by the Bureau of Land Management of the Department of the Interior. Considerable other amounts of public mineral lands are administered by the United States Forest Service of the Department of Agriculture. In a relatively few cases, lands administered by the National Park Service and several other federal agencies are also involved in mineral resource utilization. The United States Geological Survey of the Department of the Interior has supervisory jurisdiction in many aspects of federal mineral lease operations but does not actually administer any land areas (see Chapter 16).

The attitudes of the federal agencies responsible for the utilization of mineral resources on the public lands have not always been favorable to that utilization. A number of case histories cite the variety of problems that have been encountered in the use of mineral resources under federal agency jurisdiction. It should be remembered, however, that there have likewise been many instances of contact between mineral resource users and federal administering agencies that have not resulted in conflict.

Within the confines of the Grand Canyon National Park in Northern Arizona, there are some private inholdings. Among these is the mining claim on which is situated the Orphan Mine. The initial exploration of the Orphan Mine, near Grand Canyon Village on the South Rim of the Grand Canyon, was made sometime before 1900. The exploration work consisted of three adits driven into the rock strata of the canyon's south rim. Some of this development intersected uranium minerals, while copper mineralization was also encountered. Access to the workings was by way of a trail to the Coconino Rim and then by crude ladders and ropes down below the rim. The Orphan uranium orebody outcrops were at the bottom of a 600 foot cliff below the rim in Coconino sandstone. These lay about 1,500 feet vertically from the rim of the Grand Canyon, and only 17 feet from the end line of the claim involved. There was (and still is) no water on the property for drilling purposes.

In 1953, the Golden Crown Mining Company acquired the mineral rights to the Orphan claim on a purchase option from a local rancher. Surface rights had previously been separated from mineral rights by sale to the owners of a lodging facility at the village of Grand Canyon. The Golden Crown Mining Company was small, operated as a speculative venture, and did not have adequate capitalization. The mining company reached an agreement with the owners of the surface rights involving an exchange of stock options in return for enough of the surface rights to enable operation of the mine. This included the utilization of one acre of flat land on the rim plus a strip of land on which to build a tramway and unloading facility. A temporary tramway was built at the bottom of the Coconino cliff and was used to construct air and water lines and to lower building materials, drilling equipment and other supplies.

Diamond drillers engaged in the initial exploration of the Orphan uranium deposit camped in one of the adits that had been driven in the 1800's while operating a diamond drill from a station in the largest adit. The only access to the workings was along the base of the cliff by the Bright Angel Trail to the rim. During the winter of 1954 and 1955, a number of exploratory holes were drilled, but they were limited in depth to about 150 feet each because of the necessary small size of the equipment used. Nevertheless, the holes were able to outline several thousand tons of high-grade uranium ore, much of it containing more than one percent U_3O_8.

In 1955 and 1956, a permanent tramway was built and actual production from the claim began. The initial development of the mine consisted of starting on the outcrop and drifting in ore. From the first month of operation, the mine was profitable, producing approximately 50 tons per day of one percent uranium oxide for two years. As production and development proceeded, diamond drilling was continued to outline the orebody known as the Orphan Pipe. Ore was found to be continuous around the edge of this vertical pipe,

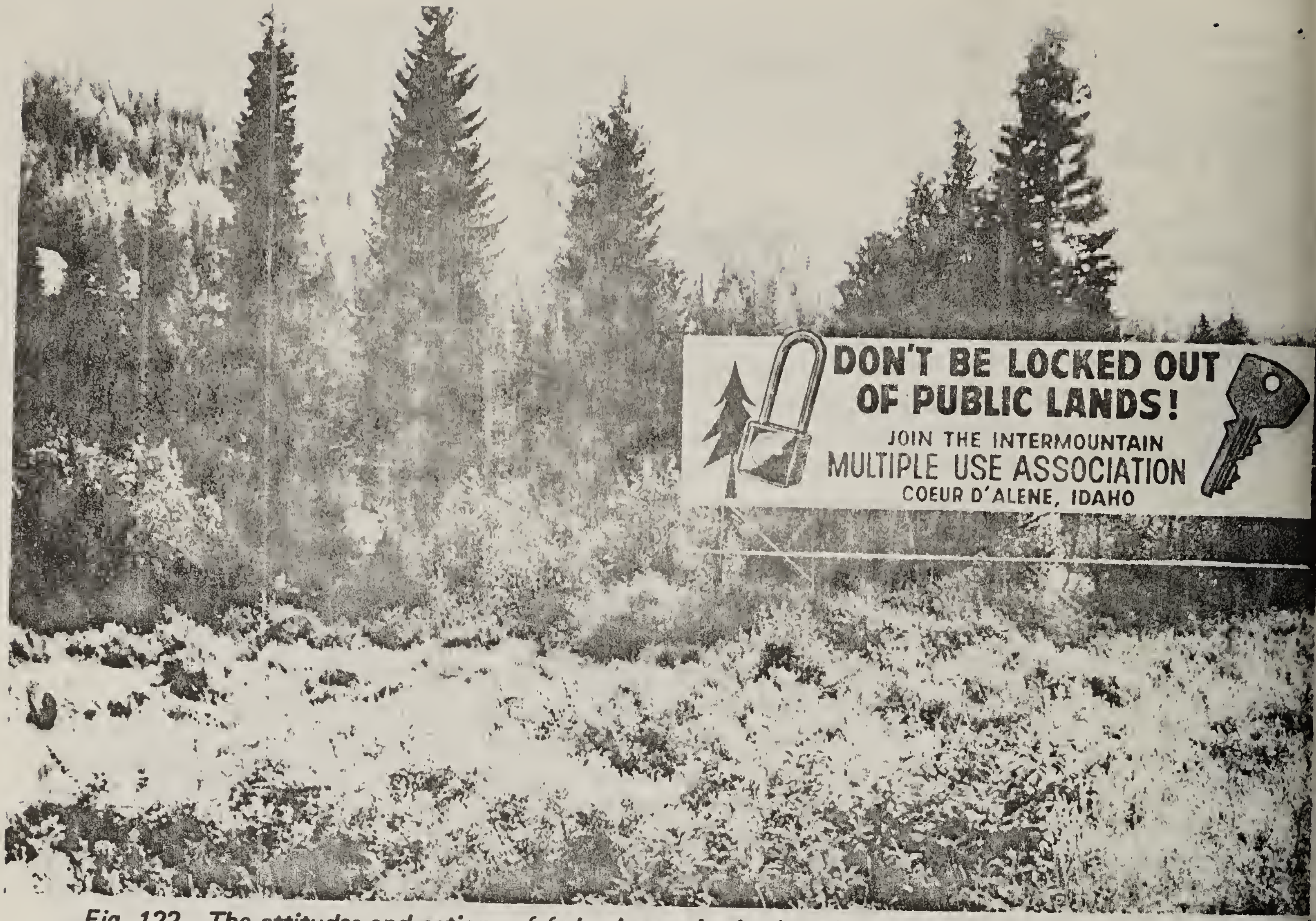


Fig. 122 - The attitudes and actions of federal agencies in the administration of the public lands have resulted in strong criticism by some present and potential users of natural resources on the public lands. Criticism has come from many interests and from many parts of the country. Some has apparently been justified, while some apparently has not.

with an area of low-grade ore containing pyrite in the center. In 1957, the Centennial Development Company began sinking a three-compartment shaft, 1,550 feet from the surface. In 1958, a crosscut was run from the shaft to the orebody and production was increased from 50 tons per day to 200 tons per day and more.

In the mid-1950's, a dispute arose between the management of the mine and the hotel owners who owned the surface rights. As a result, the mining company purchased the hotel in 1957, and it was operated thereafter as a subsidiary of the mining company. Also in 1957, the Golden Crown Mining Company was merged into Western Gold and Uranium, Incorporated. In 1967, the Orphan Mine was sold to the Cutter Corporation. By that time, it had produced over $40 million in uranium ore on a profitable basis.[83]

Despite the fact that the Orphan Mine was operated on private patented land within the outer limits of the Grand Canyon National Park area, the National Park Service has been accused (and apparently rightly so) of considerable harassment of the mine operators and distortion of the facts in their relationships with the utilizers of these mineral resources. For example, an exhibit in the park museum on the South Rim in the late 1950's stated that there had never been a profitable mine operated in the Grand Canyon National Park. This was at a time when the Orphan Mine was making a net profit of $100,000 per month. Strictly speaking, of course, the mine was not within the land of the National Park itself, because it was on a private inholding, but for all practical purposes the land is within the Grand Canyon National Park area.

Initially, a number of problems were created by the hostile relationship that existed between the National Park Service and the mining company. This situation continued for about three years, after which the relationship did improve, however. Nevertheless, employees of the Orphan Mine at first were prohibited from living in National Park Service trailer courts or cabins within the village of Grand Canyon. Likewise, the Park Service denied permission for the company to dump garbage in the National Park Service Dump maintained near the village. This denial was later rescinded. Furthermore, the Grand Canyon School denied school bus service to the children of mine employees. This resulted in the company buying its own bus to transport the children of its workers. The Park Service raised objections to the use of mining company trucks on part roads, but such objections were later retracted. The Park Service also refused to sell potable water to the company or to provide fire protection service.

After the mining company purchased the Grand Canyon Inn (which had the surface rights on the claim and was situated on the land), the Park Service refused to allow any signs or notations on the maps provided to tourists to show the existence of the Grand Canyon Inn. The National Park Service further refused to allow waste rock from shaft sinking operations to be dumped within Grand Canyon National Park, neither in the park garbage dump nor in road fills which were being constructed at the time. The Park Service also apparently used its influence to have National Forest land restricted for this same purpose. Nevertheless, a site for the dumping of waste rock was finally obtained from the United States Forest Service after a number of legal maneuvers by the mining company.

It normally takes two to make a fight, and the Orphan Mine case was no exception. In the early 1960's, the mining company announced plans for a huge hotel complex to be situated on the claim and extend out over the rim of the Canyon. Artist's conceptions of the proposed structure were published and had the almost immediate impact of offending the aesthetic senses of the Natioanl Park Service, conservationists, and the general public alike. The threat of crass commercialism on a grand scale within Grand Canyon National Park, whether an act of greed or last resort by unduly harassed mine owners, had varying effects on relationships between the mine operators and the federal government.

The Atomic Energy Commission also became involved in the difficulties between the Orphan Mine and the federal government in refusing to purchase any ore extracted from beyond the vertical projections of the end lines of the claim, even though the switching of end lines for side lines has been allowed by the courts in many similar cases. The extralateral rights that could have been obtained on the claim were thus denied by the action of the AEC.

A number of other problems arose in the utilizahion of these mineral resources that were not caused by federal agencies but were aggravated by them. All potable and industrial water for the mine had to be hauled from the distant communities of Williams or Chino Valley. Because of supply limitations, the unit cost of this water was extremely high (see Chapter 12). Likewise, the necessary use of a septictank leach field in an area where there is almost no soil was a constant problem and threat to health. Furthermore, in order to provide for legal requirements and safety, the storage of explosives had to be arranged with the Forest Service at a point six miles from the mine operation. In addition, sales of ore were permitted to Atomic Energy Commission mills only. Because of the high grade of ore, it was necessary to make contract sales to mills so far away as Salt Lake City, thus substantially increasing ore transportation costs.

The Orphan Mine case is not necessarily representative of National Park Service relationships with mineral resource users. At Organ Pipe Cactus National Monument in Southern Arizona, exploration for nonfuel minerals has been conducted for years with no serious conflicts between the Park Service and those seeking minerals. *Nevertheless, the inconsistency between the effective administration of public lands at two different locations by the same federal agency is characteristic of federal agency jurisdiction.*

Another uranium mining property in Central Arizona demonstrates some of the problems that have been involved in areas under the jurisdiction of the United States Forest Service. The Red Bluff property in Gila County, Arizona, was the initial uranium discovery in the county in 1950. Between 1950 and 1957, when the uranium ore buying station at Cutter, Arizona was closed, the mine shipped approximately 3,300 tons of ore. At the time the property and the buying station were closed, a geologist for the Atomic Energy Commission made an evaluation and estimated that the property contained *indicated* reserves of 714 tons at 0.27 percent U_3O_8 and 26,601 tons at 0.21 percent U_3O_8, for a total of 27,315 tons at a minimum of 0.21 percent U_3O_8. The Commission geologist also estimated that the property had *inferred* ore reserves of 372 tons at 0.16 percent U_3O_8 and 5,542 tons at 0.18 percent U_3O_8, for a total of *indicated* and *inferred* ore reserves of 33,229 tons at an average grade of 0.208 percent U_3O_8.[84]

In 1959, two years after the closing of the Cutter Buying Station, the small mine's owners applied for a patent on three claims and two mill sites. The United States Forest Service contested the application, and it went to hearing before a Bureau of Land Management hearing examiner in 1963, four years after the patent application. The owners felt that they had a legitimate application and appeared at the hearing with neither legal counsel nor any mineral or mining experts. The Forest Service had both legal counsel and experts, and the owners lost the decision. They fought appeals within the Bureau of Land Management structure all the way to the Secretary of the Interior. Then, in 1966, three years after the first hearing, the Secretary of the Interior, instead of rendering a decision that would either allow the claims to go to patent or the owners to get the matter into a civil court, issued a directive which stated that the case should have a new hearing under the same Bureau of Land Management hearing examiner who had heard the case in 1963. The case was, in effect, cycled back down to start all over again.

At the next hearing at the lowest level, the owners were able to obtain the services of five mineral experts, all knowledgeable in uranium deposits and all recognized consulting geologists or mining engineers. They testified in behalf of the validity of the claims. Two Forest Service experts also at the hearing asserted that material with less than 0.4 percent uranium was not ore. The hearing examiner in October 1967 ruled that the 286.7 tons of high-grade ore that did contain plus 0.4 percent uranium were insufficient to warrant the construction of a mill on a mill site. It was considered, therefore, that a *discovery of valuable mineral* had not been made on the Red Bluff mining claims, and they were therefore stated to be null and void.[85]

Despite the opinions of the Forest Service engineers at the time of the hearings procedures, ore reserves throughout the uranium industry even now commonly average much less than 0.4 percent of uranium oxide and certainly much less than that in uranium. The statements of the Forest Service engineers seem to have had no basis in mineral industry practice or the technical or economic factors involved in the property. Rather, it seems that a grade was set high enough so that the ore reserves would become inconsequential enough to justifiably invalidate the claims. The recycling of the appeals and hearings within the Department of Interior in order to prevent taking the matter outside the Department to the courts has also been a consistent practice of both the Department of the Inerior and the Forest Service.

Metals have not been the only mineral commodities affected by the generally adverse institutional environment within which mineral utilization on the public lands must take place, nor have the problems been restricted to the small miner. In the mid-1950's, an international cement company having 10 plants in operation with an annual capacity of 25 million barrels, corporate assets of $120 million, and annual sales of $70 million was attempting to acquire a patent on limestone deposits in California for the installation of a cement plant. The deposits were in an arid, isolated mountainous area on land that had no current or anticipated value other than for its limestone reserves. The total federal acreage involved in the request was approximately 800 acres.

In 1957, the company made a study of the occurrences of limestone suitable for cement manufacture within the economic range of a major metropolitan market. The initial study was carried out by the cement company itself. Early the following year, the study was reviewed by a prominent consulting firm which reached the conclusion that only one site filled both market location and quality-of-mineral requirements. As a result, in May of 1958, placer claims were staked on the particular limestone deposit in question. This involved 42 claims on federal land and 13 claims on state land. In August of the same year, state leases were granted on those 13 claims.

From 1959 through 1962, an exploratory drilling and testing program involving the expenditure of approximately $100,000 was carried out by the company.

In June of 1963, inquiry was made by the company to the Bureau of Land Management regarding the necessity for a mineral survey to accompany the patent application. The company was informed that such a survey was not necessary, but that replotting would require about two months. In August, the Bureau of Land Management notified the company that a mineral survey would be required for 25 of the claims in question. In October, patent applications were submitted to the Bureau of Land Management for 17 claims in two isolated groups. These covered the major portion of the reserves that required specific survey prior to application submission. In December of 1963, the appointment of a mineral surveyor was requested of the Bureau of Land Management, and the mineral survey was initiated.

In January of 1964, a mineral survey of an additional eight claims was requrested by the Bureau of Land Management. In August of that year, final certificates of entry were issued for the original 17 claims. In the following month, the mineral survey of the entire 33 claims to be surveyed was completed. At this same time, the Bureau of Land Management officials requested a "good faith" statement from the company regarding the patent application for the block of 25 claims. In March of 1965, approximately six months later, patent applications for the block of 25 claims, accompanied by a mineral survey and a "good faith" statement, were submitted. The application included a complete study by the company and consultants of the marketability of the product, justifying the construction of a one million barrel capacity cement plant on the site as of March 1965.

The Bureau of Land Management subsequently informally advised the company to stake a mill site claim and to drill a well on the claim to obtain the necessary water supply needed for eventual production. Bureau of Land Management officials unofficially assured the patentability of the claims. The following month, a study was made of water conditions in the area by a well-known consultant retained by the company, and as a result of his work, a mill site claim was located.

The Bureau of Land Management then requested supplemental updating of the report on the limestone claims. In May, a supplementary report on the work in progress, along with a feasibility study made by the company, was submitted to the Bureau of Land Management. At the same time a 500-foot, 16-inch diameter well was drilled by the company on the mill site claim. The following month, pumping tests were run on the well which indicated an adequate flow for industrial use of approximately 1,000 gallons per minute.

In August of 1965, the Bureau of Land Management advised the company that an economist had been added to their staff who had considered the situation. In October, the company filed an amendment to the original patent application to adjust two areas of conflict that had arisen. The following month, a patent application for the mill site was filed by the company. In December, an adverse claim was filed by a claimant who had jumped one of the company's claims after patent procedures had begun. The adverse claim was recognized by the Bureau of Land Management.

In February of 1966, a patent on the mill site was rejected by the Bureau of Land Management on the basis of a technicality in the preparation of the application. The following month, the patent for the mill site claim was refiled by the company. At the same time, the Bureau of Land Management requested a report by a title search company on the mill site claim. In July, three months later, the Bureau of Land Management issued a final certificate of entry on the mill site claim. The following month, the Bureau of Land Management advised the company that the patent for the mill site claim had been rejected, because the site was not in present use for milling. In September, the company requested the Bureau of Land Management to hold the mill site patent application in abeyance in order to find a way to protect their investment in the well and established water supply source.

A year passed, and more. In May of 1968, the adverse claim on one of the limestone claims was settled out of court. The Bureau of Land Management then issued a final certificate of entry for 23 claims, i.e., for the major portion of the area covering the known limestone reserves. In March of 1968, the Bureau of Land Management informally advised the company to drop patent proceedings on the remaining mining claims since they would be opposed by the Bureau on the basis of "excess reserves." In September, a survey for a pipeline right-of-way was initiated by the company to protect the water well and supply.

As of October of 1968, no final decision had been made on the patent application for the major portion of the reserves required to justify some plant installation, and no tenure had been obtained by the company on the land containing its source of industrial water. This was in spite of the fact that more than 10 years had been involved in exploration and development, as well as in the legal proceedings with the federal agency having jurisdiction over the area. In addition to the time spent, a direct expenditure of $60,000 had been made on assessment work drilling and on the locating of claims. An additional $100,000 had been spent on engineering work, including feasibility studies, surveys, and the testing of mineral samples. Further, $60,000 had been spent on field fees and $15,000 had been spent on water location and development of the water supply. This amounted to a total of $225,000 over the 10-year period. Even with the expenditure of this time and money, the company still had no firm tenure on the land containing either water or limestone.[86]

Not all mineral patent applications have been so difficult, even those involving placer claims. In the mid-1960's, placer gold claims were applied for and obtained on a large acreage of land in Central Arizona, just west of the Phoenix urban area and in a region expected to see the construction of an important link in the Interstate Highway System and a major aqueduct transferring water from the Colorado River to the Phoenix Metropolitan Area under the Central Arizona Project. Despite strong circumstantial evidence to indicate that the claims were associated with real estate speculation, patents for the extensive area were issued in relatively short order. The patents were later revoked, however, when it was discovered that the samples taken in the area by the Bureau of Land Management had been *salted,* i.e., fraudulently enriched with gold not actually from the area.

With the Bureau of Land Management, as with other federal agencies, *inconsistency in administration* has been the most consistent characteristic in public mineral lands jurisdiction. This has made the institutional environment within which mineral utilization must take place an extremely uncertain environment. Political and legal conditions have, in fact, become far more uncertain than either geologic or economic conditions. This has had an extremely adverse effect on the effective utilization of minerals on the public lands, but the effect has not been quantifiable.

2. Land Withdrawals

In addition to the practices followed by the federal agencies responsible for public land management, the withdrawal of land from mineral location has also influenced the environment in which mineral resource utilization must take place. As an example, in the Tucson Mountains, immediately west of the city of Tucson, Arizona, a park was established (by recreational withdrawal number 21 issued April 29, 1929) for administration under lease by Pima County. Mining interests participated in securing the original withdrawal, and one of the individuals originally involved in the withdrawal in fact stated, "The main purpose of the withdrawal was to stop homesteading in the area. There was never any objection to mining. This land was definitely established as mineralized land before its withdrawal."[87] The original withdrawal of land for Tucson Mountain Park included approximately 26,000 acres of federal land, as well as some 6,500 acres of state school lands.

The land under lease to the County was subsequently closed to mineral exploration and mining activity. The lease, however, expired in December, 1954. Not quite a year later, the question of mining within the Park was raised by the Banner Mining Company. In a letter to the Bureau of Land Management in August of 1955, Banner requested the necessary regulations governing mining on 1,000 acres of mineralized land within the park. The request was made under an erroneous assumption by the company that Pima County had leased the 1,000 acres in question. The request was further prompted by the belief that holders of the surface rights should be protected and the park and recreational purposes of the area reserved. The letter offered to cooperate in every way so as not to interfere with any park or recreational use for the area. The offer was made with the knowledge that mineral resource utilization and recreational uses of the land are not mutually exclusive nor antagonistic.

In 1957, the Bureau of Land Management completed a mineral classification for the park area, and the geological report showed that 7,600 acres were *mineral* in character. In August, 1959, Assistant Secretary of Interior Hearnst signed an order to open the 7,600 acres of mineral land in the eastern portion of the park to mineral exploration and development. The designated area lies along the northward extension of the Twin Buttes-Pima mineral belt, and contains a substantial number of old mine sites and valid mining claims, including the major portion of a new discovery located just south of the park border.

Of the 7,600 acres declared to be mineral in character, only about 800 had even been leased to the county for actual park use. Nevertheless, objections were raised to mineral resource utilization in the area. As a result, the land order was suspended and a hearing was held in Tucson regarding the withdrawal area. Only arguments opposed to mineral use were heard the first day of the hearings, which was held before a large and emotional audience. A much smaller group was on hand the second day when the mining industry presented its side of the case. The order to open a portion of the park to mineral location was rescinded by the Department of the Interior in December of 1959.[88]

As a result of the original withdrawal and the continued existence of the withdrawn area, a significant amount of mineral resources in a highly mineralized and geologically (as well as economically) attractive area were kept from utilization. As an aftermath of the ruling, most of Tucson Mountain Park was taken from county use and made a portion of Saguaro National Monument, administered by the National Park Service.

Withdrawals of land for nonmineral purposes have not been confined to Arizona or the Southwest. As shown by Table 26, withdrawn acreages have also been substantial in the Pacific Northwest. A similar pattern has been followed in other parts of the West. Most of the land withdrawn from mineral use in the past decade has been for recreational and similar purposes upon which it is difficult to place economic criteria.

3. The Unpatented Mining Claim

The unpatented mining claim (see Chapter 16) has become of increasing importance in the Western United States since the early 1960's. As shown by Table 27, more than three million claims have been filed with local officials in the various counties of the West since 1960. Only about 5,000 claims, however, have been involved in patent application proceedings with the Department of the Interior since 1960. Of these claims, only about 2,500 have been recommended for patent.

The number of patent applications investigatedand classified by the Department of the Interior has dropped sharply from the peak reached in 1960. The number of patent applications acted upon favorably (for the mineral claimant) has likewise declined since 1960, although the number of such applications has remained a relatively low level since 1964. On the other hand, the number of claims approved for patenting has increased substantially since 1960. This indicates that the applications approved have involved larger areas, while an increasing proportion of the applications for small areas have not been recommended for patent.

This does not necessarily reflect a decreasing real validity in small claims, however. Rather, it reflects an awareness on the part of the small claim holder that his patent application would probably be denied, thus invalidating even his unpatented claims and destroying his rights to use the land for mineral purposes. As a result, since the early 1960's, small mineral claimants have been extremely reluctant to file patent applications and have preferred to produce from unpatented claims. Most of the cases involving small claimants

Table 26

PROPOSED WITHDRAWALS OF LAND FROM MINERAL LOCATION IN OREGON

Year	Number of Withdrawals	Acres
1957	17	20,402
1958	5	44,323
1959	12	20,737
1960	4	1,287
1961	7	9,353
1962	20	30,480
1963	9	9,304
1964	12	46,658
1965	14	15,944
1966	15	37,775
1967 (to September 21, 1967)	14	7,002
TOTAL	129	243,265
Average per year	12	22,115

Source of data: Oregon State Department of Geology and Mineral Industries.

Table 27

ESTIMATED NUMBER OF CLAIMS FILED PER YEAR IN THE WESTERN STATES 1961-1966

Year		Number of Claims Filed (Pima County, Arizona)	Estimated Number of Claims Filed in the 11 Western States
1961		3,082	677,964
1962		1,948	433,748
1963		1,091	242,036
1964		2,439	542,195
1965		2,245	499,227
1966		2,685	596,050
1967		3,287	NA
	Total	16,777	2,991,220

Source of data: Pima County claims from official County records; estimate for the 11 Western States by the Division of Economic and Business Research, The University of Arizona.

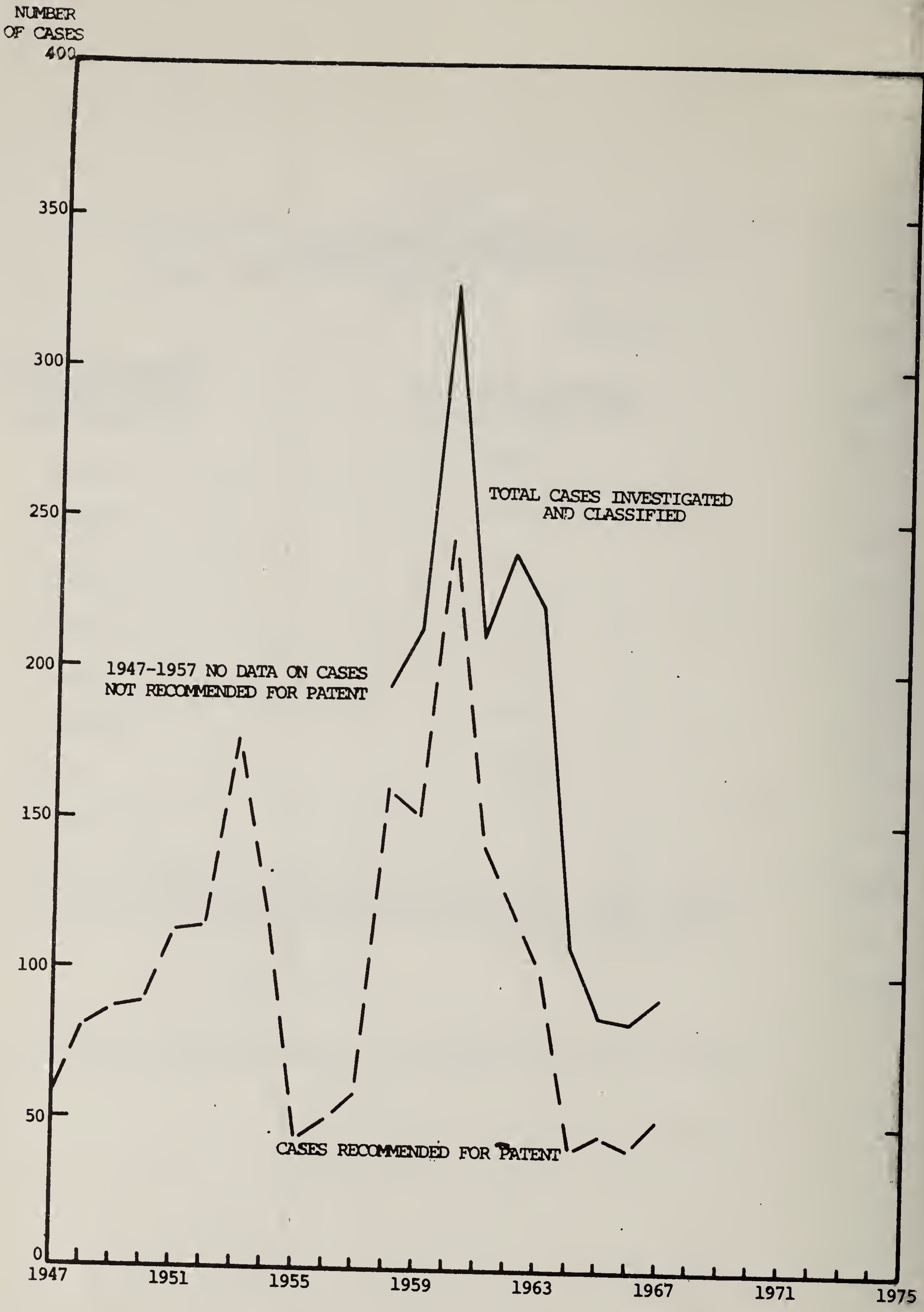


Fig. 123 - The number of mineral patent applications investigated and classified by the Department of the Interior has dropped sharply from the high reached in 1960.

that have been brought to examination since the early 1960's have been initiated by the Forest Service in a deliberate attempt to have the small miners and prospectors (and some abusers of the mining laws) removed from National Forest lands.

4. Reserved Mineral Rights

The existence of mineral rights separate from surface rights to date has resulted in a surprisingly small number of conflicts between users of the land. As noted in Chapter 6, however, the presence of mineral rights in the public domain in those areas where surface rights (and uses) have passed to private hands has a definite potential for future conflicts between mineral users and other users of the land.

So far, most of the conflicts that have arisen as a result of severed and reserved mineral rights have not been *bona fide* conflicts between different uses of the land, but rather the result of attempts to abuse the public laws by unscrupulous real estate promoters or thinly disguised extortionists.

In the early 1960's, one group staked land in the Casas Adobes suburb of Tucson, Arizona, purportedly for placer deposits of iron and other minerals. These claims were then offered for sale to the homeowners occupying the surface. Through lengthy proceedings, the claims were declared invalid and the land was subsequently withdrawn by the federal government from mineral location. At the other extreme, sand and gravel deposits adjacent to or near cities have often been difficult to acquire because of the Bureau of Land Management's reluctance to disturb the surface owner, even where the surface consists solely of low-quality grazing land.

In other instances, unscrupulous real estate developers have laid out "subdivisions," bulldozed "streets," and sold lots (by mail and otherwise) on reserved mineral land in semi-active mining districts in which *bona fide* exploration work was being done. Old mine shafts were described as "abandoned wells" to unsuspecting lot purchasers, and other devices were used to obscure the potential threat to the use of the land for residential purposes.

Many conflicts have been more imaginary than real. Claims were staked by Bear Creek Mining Company on mineralized ground west of Tucson and near Tucson Mountain Park in the period from 1959 to 1962. One claim extended across the small tract of a homeowner, who subsequently objected to the bulldozer trench dug for location work "in his backyard." This was despite the fact that the trench was not in immediate proximity to his house. (See Chapter 16 for a discussion of the legal requirement for such trenches.)

The encroachment by urban and real estate development on agricultural and mineral lands (containing primarily sand and gravel, mercury, and silica) in California has been well-documented. The elimination of these mineral resources has resulted in higher costs to both public and private consumers, as agricultural and mineral products have had to be hauled in from much greater distances away. Some sand and gravel for the San Francisco Bay area is hauled in from more than 100 miles away. Useable deposits occurring at closer distances have become extremely valuable, as the cost of transportation constitutes a growing component of the product's delivered cost to the buyer. California has recognized the problem and has made provisions for the extraction of mineral deposits prior to release of land for urban and suburban development. Decisions of priority, however, have been subjected to political considerations and influence, so that in practice these provisions have been less than completely effective.

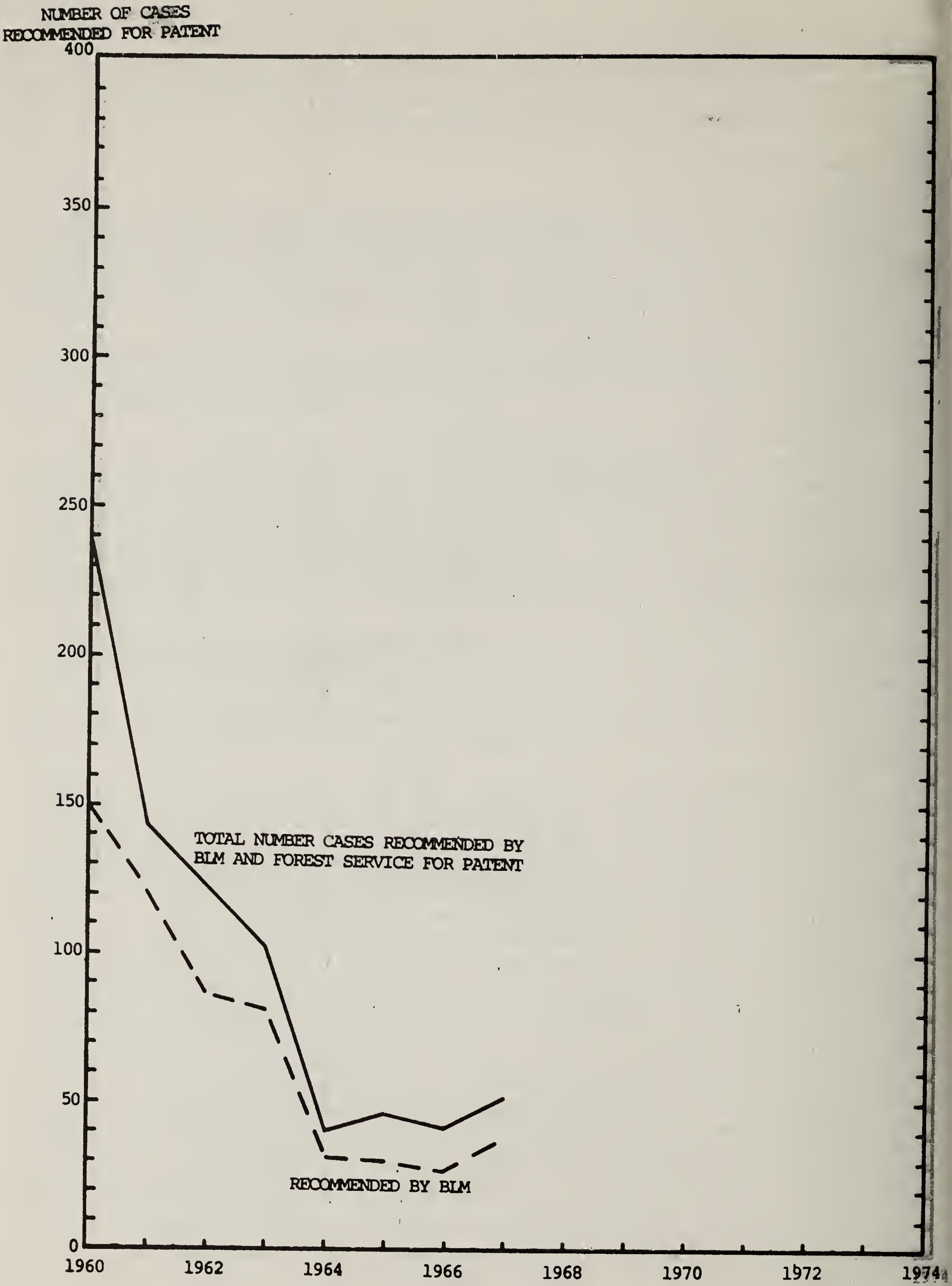


Fig. 124 - The number of mineral patent applications recommended for patent by the Department of the Interior has remained relatively stable since 1964 at a level well below that of 1960.

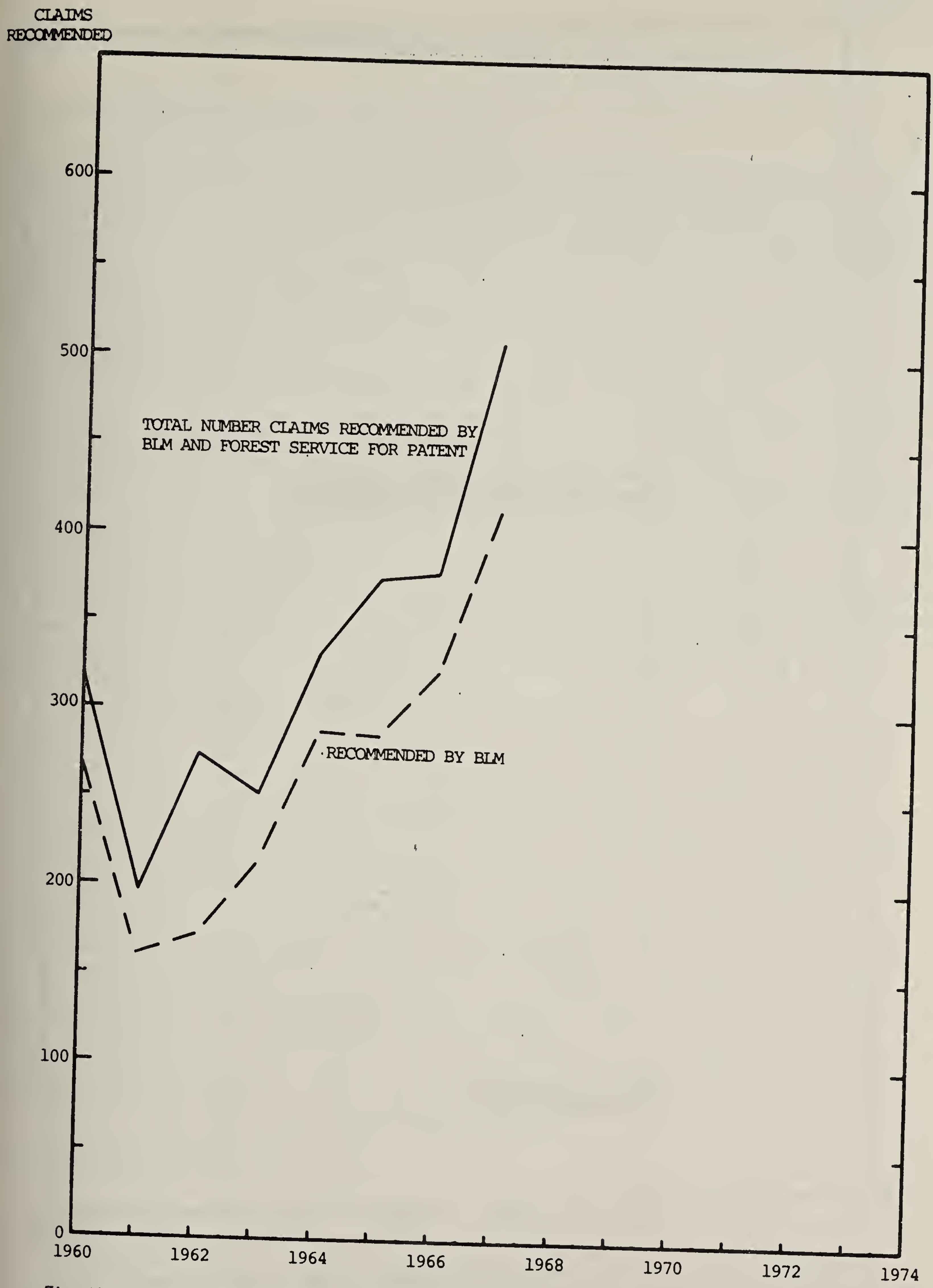


Fig. 125 - The number of claims recommended for patent by the Department of the Interior has climbed sharply since 1961, reflecting a more favorable attitude towards mineral claimants of large areas and an adverse treatment of small area claimants.

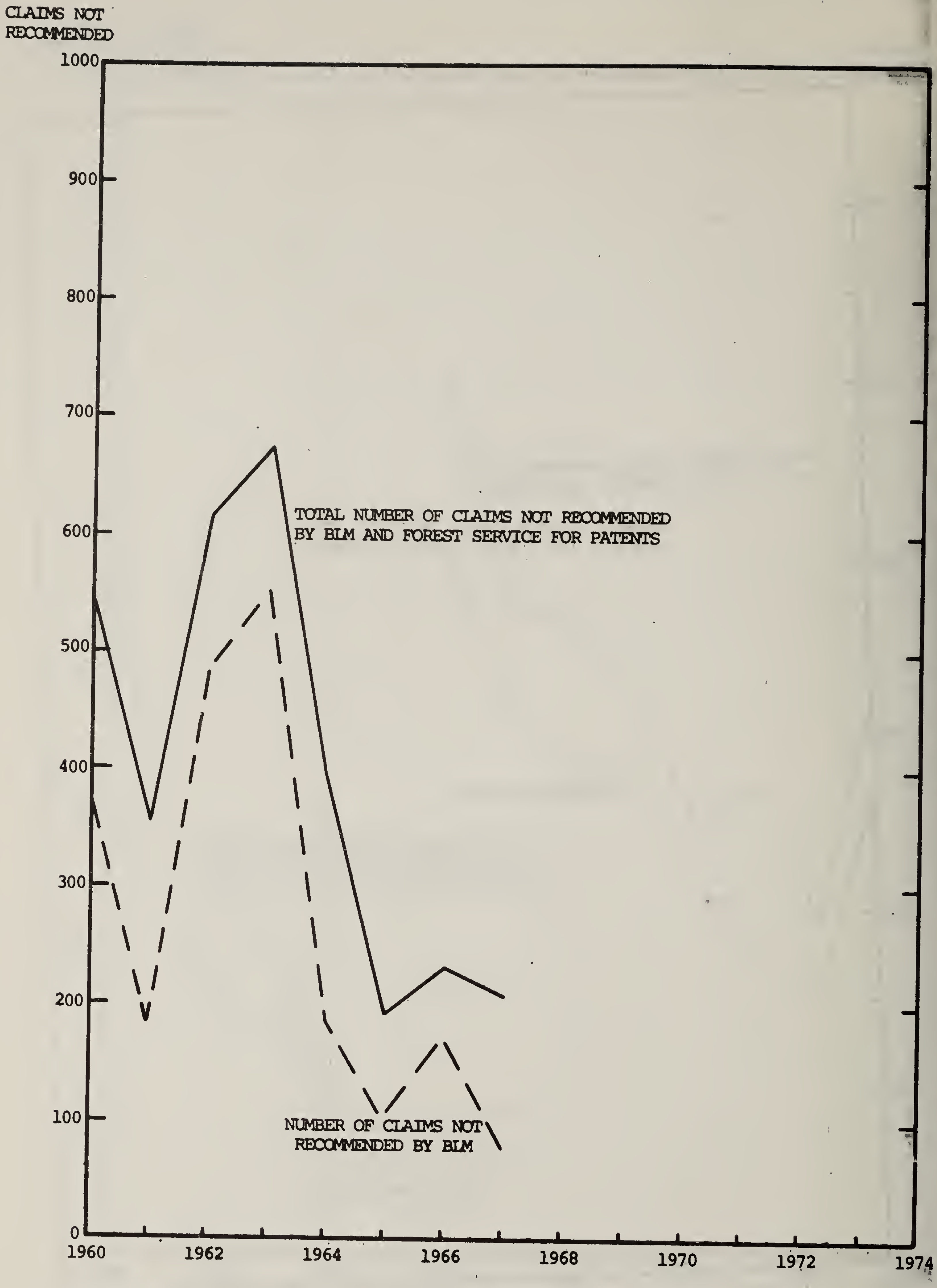


Fig. 126 - The number of claims not recommended for patent by the Department of the Interior since 1965 has been well below the high reached in 1963, reflecting a reluctance on the part of small miners to apply for mineral patents.

C. MINERAL RESOURCES AND AGRICULTURAL LAND USES

1. Effects of Mineral Use Upon Grazing Activities

Of all the real and imagined conflicts between the utilization of mineral resources on the public lands and the utilization of the public lands for other purposes, perhaps the least consequential is that which exists in a few instances between the use of land for mineral purposes and for grazing purposes. During the exploration stage of mineral resource utilization, there is virtually no conflict whatsoever between the two uses of the land. In fact, in many cases the utilization of the land for mineral purposes enhances its use for grazing purposes. This mutual enhancement occurs where water catchments and roads providing access to remote areas (so that water supplies for cattle may be brought in) are installed by mineral resource users.

It is true that the surface of the land immediately occupied by an open pit mining operation is not immediately available for grazing use. In most parts of the arid and semi-arid west, however, that land devoted to mineral industry uses results in a product far more valuable than that same amount of land devoted to grazing. In fact, of all the real and potential *commercial* uses of the public lands, grazing is probably the least productive in terms of the value of output for a given surface area of land. Mining, on the other hand, is one of the highest. If the contrast is made on other than economic terms, the measurement becomes the opinion of the observer.

In areas adjacent to actual mining operations, the utilization of land for grazing purposes is frequently enhanced by the presence of mining operations. Mineral resource utilization aids grazing principally by providing means of access to nearby areas for those who manage livestock resources on the land and in providing catchments and other means by which water is made available to these livestock resources.

For all practical purposes, the use of land for grazing purposes has virtually no effect on mineral resource utilization on the public lands of the United States. That is to say that the *use* of the land for a particular purpose in and of itself has no effect. Many times, however, the ownership of surface rights (but not mineral rights) by grazing interests does result in a hindrance to normal mineral exploration activity by *bona fide* mineral seekers. It has not been infrequent in the West that vandalism by the general public has caused grazing interests to attempt to exclude all persons from public lands upon which they own the surface rights but not the mineral rights. This has tended to hinder *bona fide* minerals exploration. In most instances, however, where men of open minds have conducted the mineral search and others of similar attitude have owned the grazing rights, mutually advantageous adjustments have been made so that one use of the land has been able to accommodate the other.

The number of instances of cooperation and accommodation between grazing rights owners and *bona fide* minerals seekers and producers has been far more numerous than the instances of conflict. Unfortunately, those relatively few instances of conflict have received much more notoriety than the instances of cooperation. In many instances, *bona fide* minerals exploration firms, in developing new sources of water, have enhanced the subsequent use of grazing areas even where no mineral deposit has been found. This is a much more widespread occurrence than is commonly realized.

2. Mineral Resources and Crop Agriculture

Throughout the public land areas of the West, there has been relatively little incidence of conflict (or even contact) between mineral resource utilization and utilization of the land for crop agriculture other than forage crops. In virtually every instance where there has been some conflict between mining and agricultural activities, it has not been over the land itself but has concerned the mutual or exclusive utilization of water resources. In general, those areas that have been most attractive geologically (as well as economically) for minerals exploration, development, and production have not been those areas most attractive either

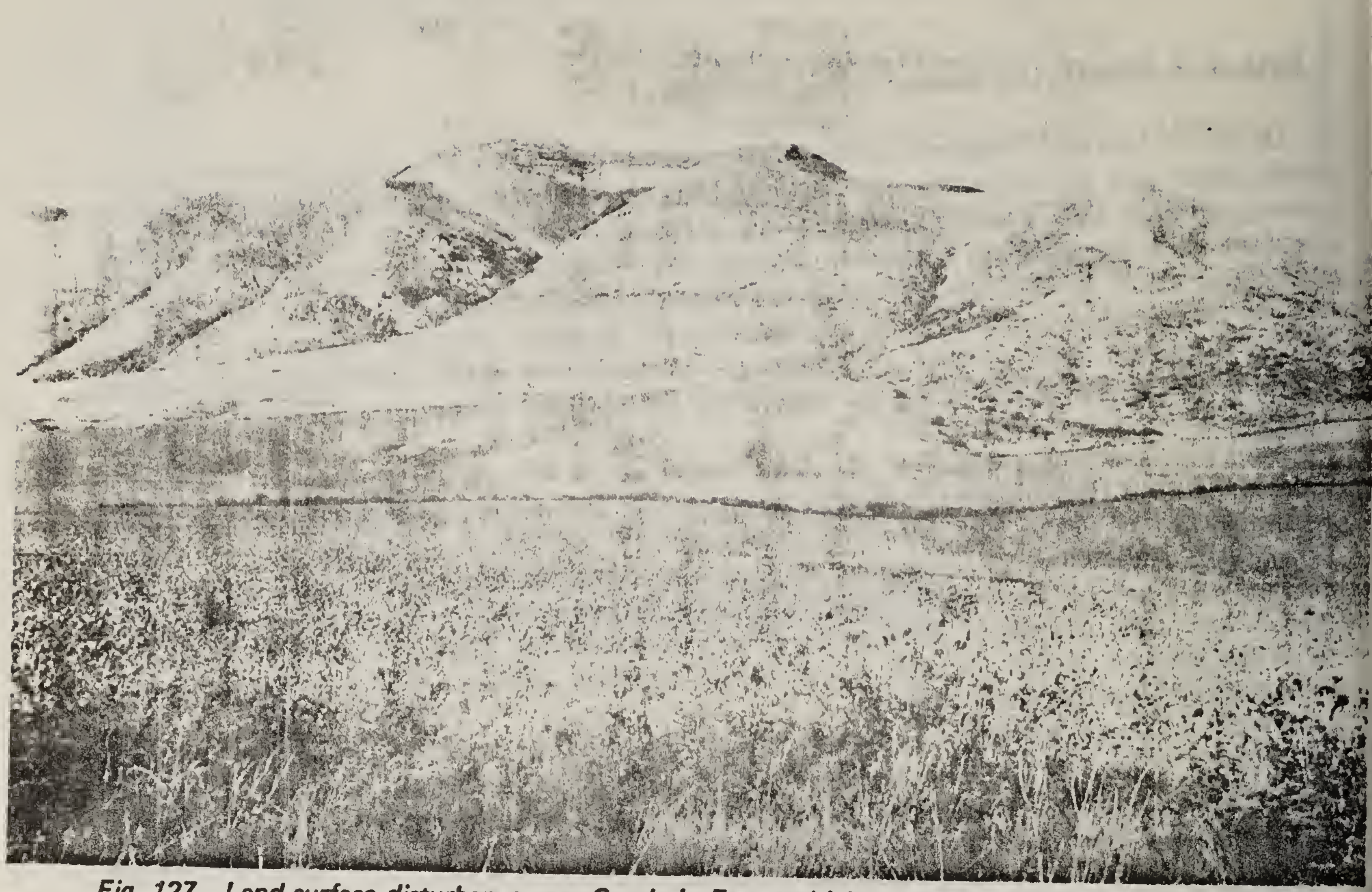


Fig. 127 - Land surface disturbance near Conda in Eastern Idaho. Foreground disturbance is the result of agricultural operations. Disturbance caused by mining operations may be seen at the top of the hill in the background.

economically or technically for the raising of crops.

Probably the major exception to this lack of conflict between mining and farming has been in the Central Valley of California, where placer mining operations were conducted in the relatively level, potentially rich agricultural areas. Nevertheless, most of the conflict that did arise in this area concerned water and not the land itself as soil or surface space.

The same has been true elsewhere throughout the West, where various activities competing for limited supplies of water have been in conflict. This has been at times a serious problem for certain localities, and in the future it can be expected to become an even more serious problem as numerous and diverse users compete for what is becoming an even more limited supply of useable water. Competition between crop agriculture and mineral resource users for the land itself, however, is likely to remain minimal over the next two decades. The beneficial effects of mining activities upon agricultural land use are likely to continue.

The benefits derived by agriculture from mineral resource utilization are two-fold. Probably the most beneficial aspect of mining includes the amounts of phosphates, potash, sulfur, lime, gypsum, and other industrial minerals produced specifically for agricultural purposes as fertilizers or soil conditioners. The other major aspect involves the improved availability of mined land for agricultural uses once mining activity has ceased. It has been found that grasses, legumes, and cultivated plants will grow successfully on areas that have been strip mined—in some cases, better than before mining. For example, in Virginia, hay production on some reclaimed mining areas has been 50 percent greater after mining than before.[89] In many other areas, improvement of the agricultural use of the land has been the net result of mineral resource utilization.

Fig. 128 - Agricultural activity between Conda and Soda Springs in Eastern Idaho in the immediate vicinity of surface phosphate mining operations and only a few miles from the elemental phosphorus plant operated by the Monsanto Company.

Fig. 129 - Apple orchard near Wenatchee, Washington. Nearby, a tailings storage area developed by a former gold mining operation has been covered with topsoil and also planted with apple trees, thus creating useable orchard land where only barren rock had existed previously.

D. MINERALS AND FOREST RESOURCE USE

The utilization of nonfuel mineral resources in the Western United States has had relatively little effect, adverse or otherwise, upon the utilization of the West's forest resources. This has been so primarily because the bulk of the region's nonfuel minerals output comes from semi-arid areas where commercial forestry does not exist. In the Rocky Mountains and in the Northwest, however, there have been some interactions between mineral and forest resource use.

Abuses of the mining laws have been of far greater significance to forest resource utilization than have *bona fide* mining operations. In New Mexico, for example, one party prevented the use of approximately 120 acres of National Forest timber lands for a year by covering the area with mining claims. Another prevented the use of 900 acres in a similar manner.[90] Whether or not these represented valid mineral exploration activity is not known, but the existence of these unpatented claims, at least purportedly staked for mineral purposes, did hinder the effective utilization of forest resources for the time that they were there.

In Southern Oregon, the construction of some logging roads has been seriously hampered or prevented by the presence of unpatented placer mining claims. Similar difficulties have also occurred in the Coeur d'Alene National Forest in Northern Idaho. Perhaps of far greater significance, however, is that the western timber industry's trade association has reported no instances of serious conflict in recent years between mining interests and commercial timber interests in Washington, Colorado, Utah, or Montana.[91]

Cooperation between mineral and forest resource users has, in fact, been the rule rather than the exception throughout the entire Western United States. A survey of large and small mine operators in the West in 1968, revealed that only three percent of the active mining properties in the region had any significant problems of conflict with the users of forest resources. Most of these were actually administrative conflicts with the Forest Service rather than with commercial timber interests.

In some areas, the utilization of mineral resources has actually enhanced the use of forest resources. Many reclaimed mining lands in the Eastern United States have been successfully planted with trees. In some cases, post-production tree planting has created forest resources where none had existed before. In other areas, the disturbance of the surface by mining operations has improved forest growth. Some of the fastest growing yellow pine forests in the United States are situated in the Sierra Nevada foothills of California on land once mined by hydraulic methods.[92] Where the climate permits, similar situations exist throughout the public land areas of the West.

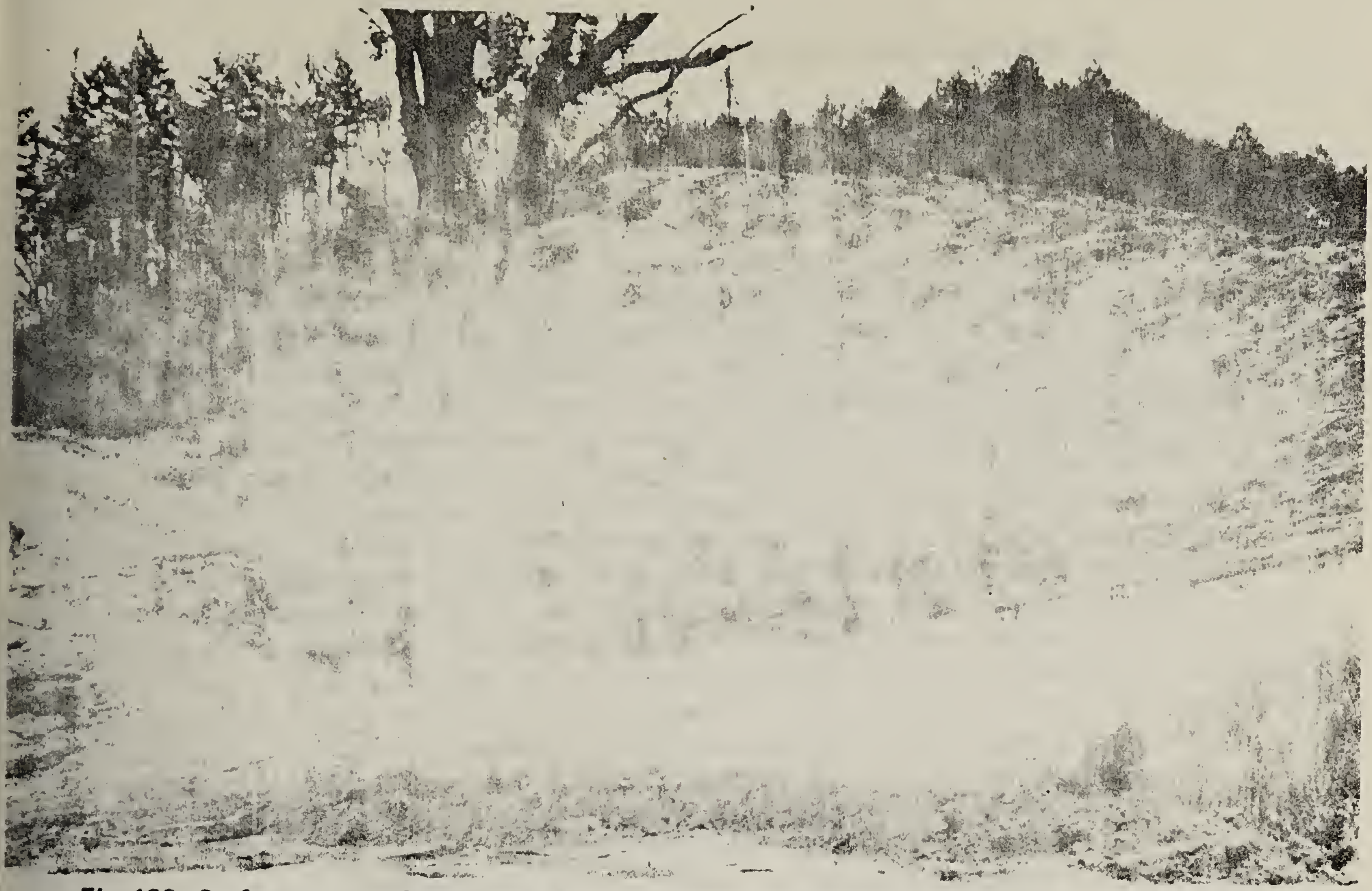


Fig. 130 - Surface cleared of timber preparatory to use of the land for mineral purposes in Oregon. Most currently active mineral districts in the West are in semi-arid regions that have a minimum of forest cover. New exploration techniques, however, could make forested areas more important as sources of minerals.

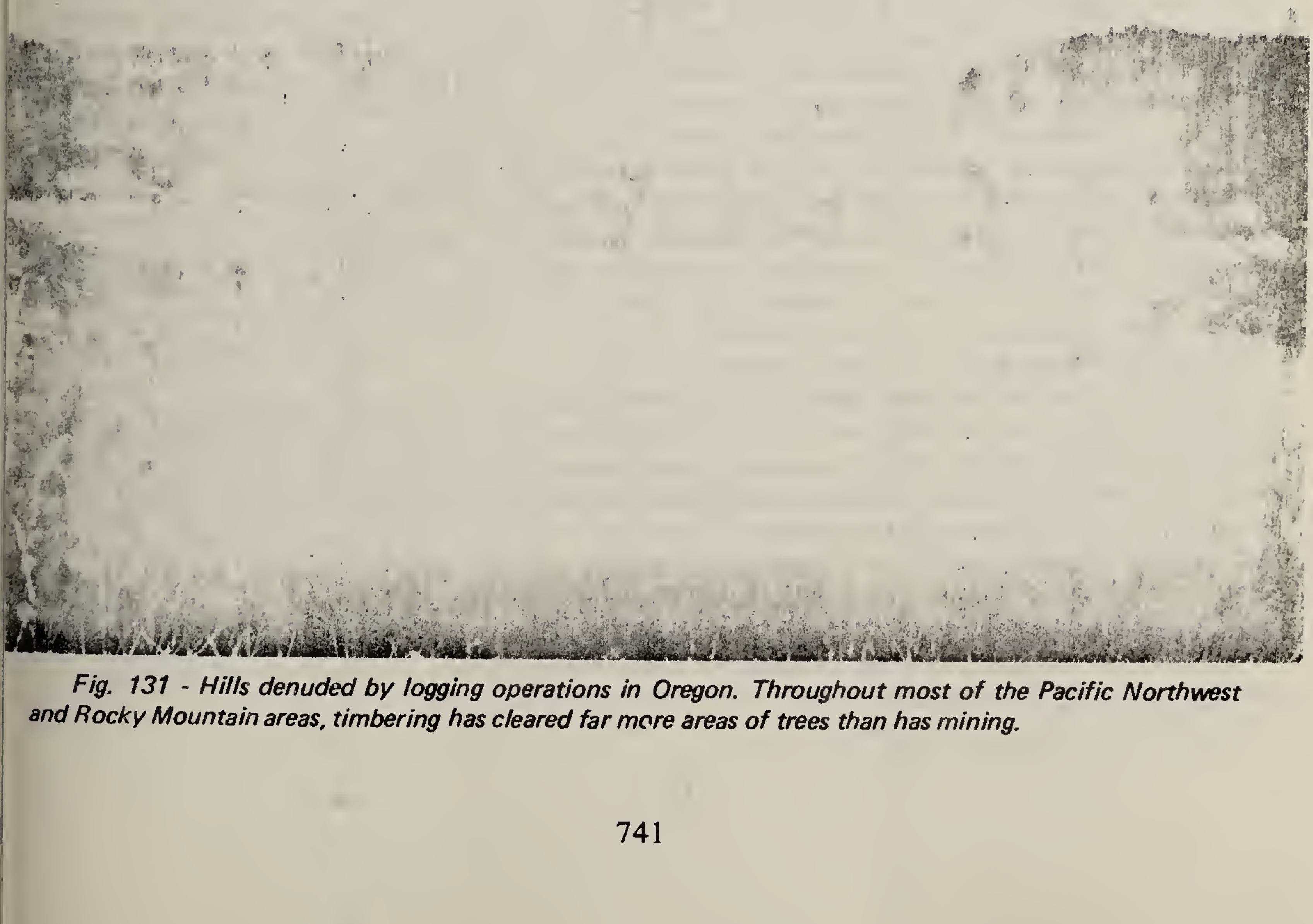


Fig. 131 - Hills denuded by logging operations in Oregon. Throughout most of the Pacific Northwest and Rocky Mountain areas, timbering has cleared far more areas of trees than has mining.

E. MINERAL RESOURCES AND RECREATIONAL LAND USE

The real and imagined conflicts between users of mineral resources and other users of the public lands have been perhaps most notorious between the mining industry and those who would use the land solely for recreational purposes. This is in spite of the fact that mineral resource utilization and recreation are not inherently antagonistic and, in fact, are *synonymous* in many areas throughout the Western United States and in other parts of the nation as well. Virtually all of the surface mining operations located on major United States highways have viewpoints or some other facility (usually constructed by the operating mining company itself) to provide travelers an opportunity to view mining operations from the safety of the pit rim. Many of these viewpoints are well attended, although exact visitor counts are not available. In many cases, such counts are not available simply because it has never been considered necessary to prove the value of mine viewpoints as tourist attractions.

Mining operations of the past are undoubtedly an even greater tourist attraction. Throughout the Western United States, state parks have been established at many of the sites of 19th Century mining operations. In California, the ghost town of Bodie, near the Nevada border, has been established as a state historic park and is operated as a unit of the California State Park System. In San Bernardino County, the former mining town (and still potentially rich silver area) at Calico, near Barstow in the Mohave Desert, has been made a county park and is operated by a concessionaire as an apparently lucrative tourist attraction.

In the gold rush country of the western Sierra Nevada foothills near Grass Valley and Nevada City, California, considerable attention is paid by those interested in attracting tourists to the historical significance of the area. The prior mining use of the land in that district remains a significant tourist attraction and of considerable value for recreational purposes. The site of Sutter's Mill, where gold was discovered to begin the California Gold Rush of 1848 and 1849, is now a state park and is operated by the State of California for recreational purposes. Throughout most of Central and Southern California, mining operations of the past today comprise a significant recreational use of the land.

Even old mining sites without particular historic interest are now being used for recreational purposes. At Lancaster, California, on the southern edge of the Mohave Desert about 80 miles east of Los Angeles, a borrow pit formerly used for the excavation of construction materials has been converted to an aquatic park, containing three lakes with a combined surface area of 19 acres. This recreational use of a former mining area is also significant in that it allows the utilization of waste water from urban uses that would otherwise be lost.[93] The similar use of mined-out surface pits for water recreation purposes is widespread throughout those areas of the United States where water is readily available and (as at Lancaster in the Mohave Desert) even in some places where it is not.

From Florida to Washington, where there is moderate to heavy rainfall, the use of old mining excavations or recently terminated mining operations for recreational purposes is common. Even in Boston, where the Quarry Preservation Society has been formed by interested citizens, the pit excavated by an old quarrying operation is now used for recreational purposes. This is despite the fact that throughout Massachusetts there is considerable opposition to the creation of new quarries to produce badly needed construction materials.

In many areas along the Pacific Coast, past and present mining operations are also significant in the recreational use of the land. In Oregon, the State Highway Department regularly publishes information concerning ghost towns, mining museums, rockhound sites (and areas where the amateur may prospect just for the fun of it), old mine sites, and active mines as an integral part of their tourist information service.The Chamber of Commerce of the city of Prineville in Central Oregon maintains a mining claim specifically as a site for rockhounds visiting the community. In June 1968, as part of its centennial celebration, the community of Prineville held a *miners and prospectors weekend* with a special invitation to rockhounds to visit the area and engage in their hobby. The following month they held another rockhound *powwow.*

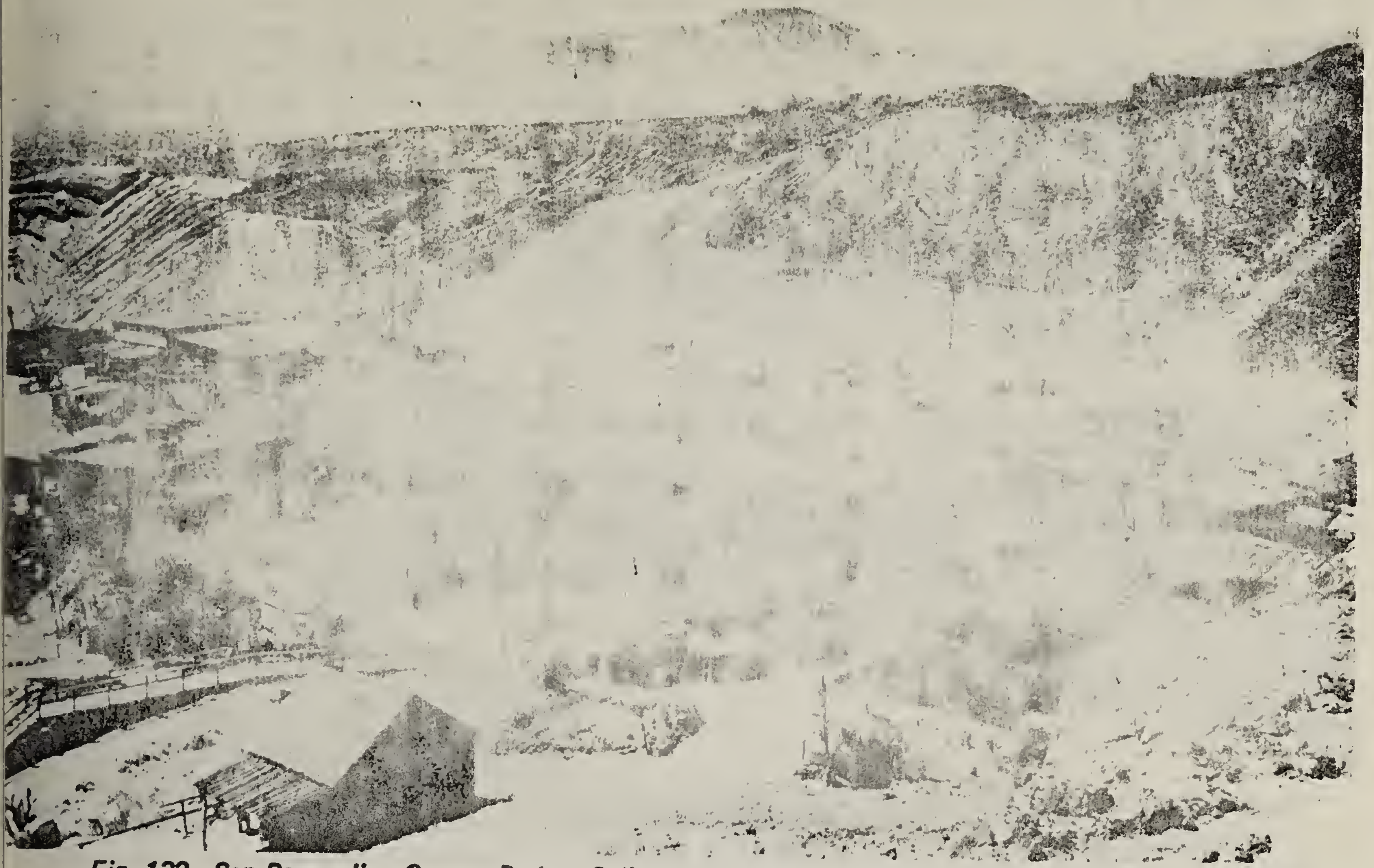


Fig. 132 - San Bernardino County Park at Calico, near Barstow, California. Calico is the site of formerly active silver mining operations, and the mountain in the background reflects geologic evidence of strong subsurface metallic mineralization. The site is now popular for recreational use solely because of its past mining activity. Other old mining camps are popular tourist attractions throughout the entire Western United States. Sometimes their attraction is enhanced by the nearby presence of active mining operations.

The area also has had past commercial mining activity. A significant gold strike was made in the area 30 miles east of Prineville in 1873 and resulted in the subsequent production of $2.5 million in gold and silver. The district was also the site of active mercury mines in the late 1890's. Today, the area is known for its deposits of semiprecious stones and Prineville, in fact, refers to itself as the agate capital of Oregon. With considerable numbers of rockhounds attracted to the Prineville area for recreational purposes, the availability on the public lands of mineral resources for their recreational use has become a significant tourist attraction for this community. Similar conditions are common throughout many of the Western States.

In 1968, a survey of visitors conducted by The University of Arizona at Organ Pipe Cactus National Monument indicated that many winter visitors to Southern Arizona are hobbyists who are attracted by and utilize available public lands for the collection of mineral specimens. *Rockhounds* are a significant portion of the total tourist travel to Southern Arizona. Although they do not collect specimens on National Park or Monument lands, they do make extensive use of known deposits on lands administered by the Bureau of Land Management. Many retired persons travelling throughout the West have utilized well-known deposits of semiprecious stones for recreational purposes. Many of these deposits have, in fact, become destinations for these people in pursuing their hobbies.

In Washington, it has become the practice of the State Highway Department to grade and landscape the borrow pits used for the production of sand, gravel, and other construction materials utilized in highway construction and to allow them to fill, forming small recreational lakes throughout a series of roadside parks. Particularly in Western

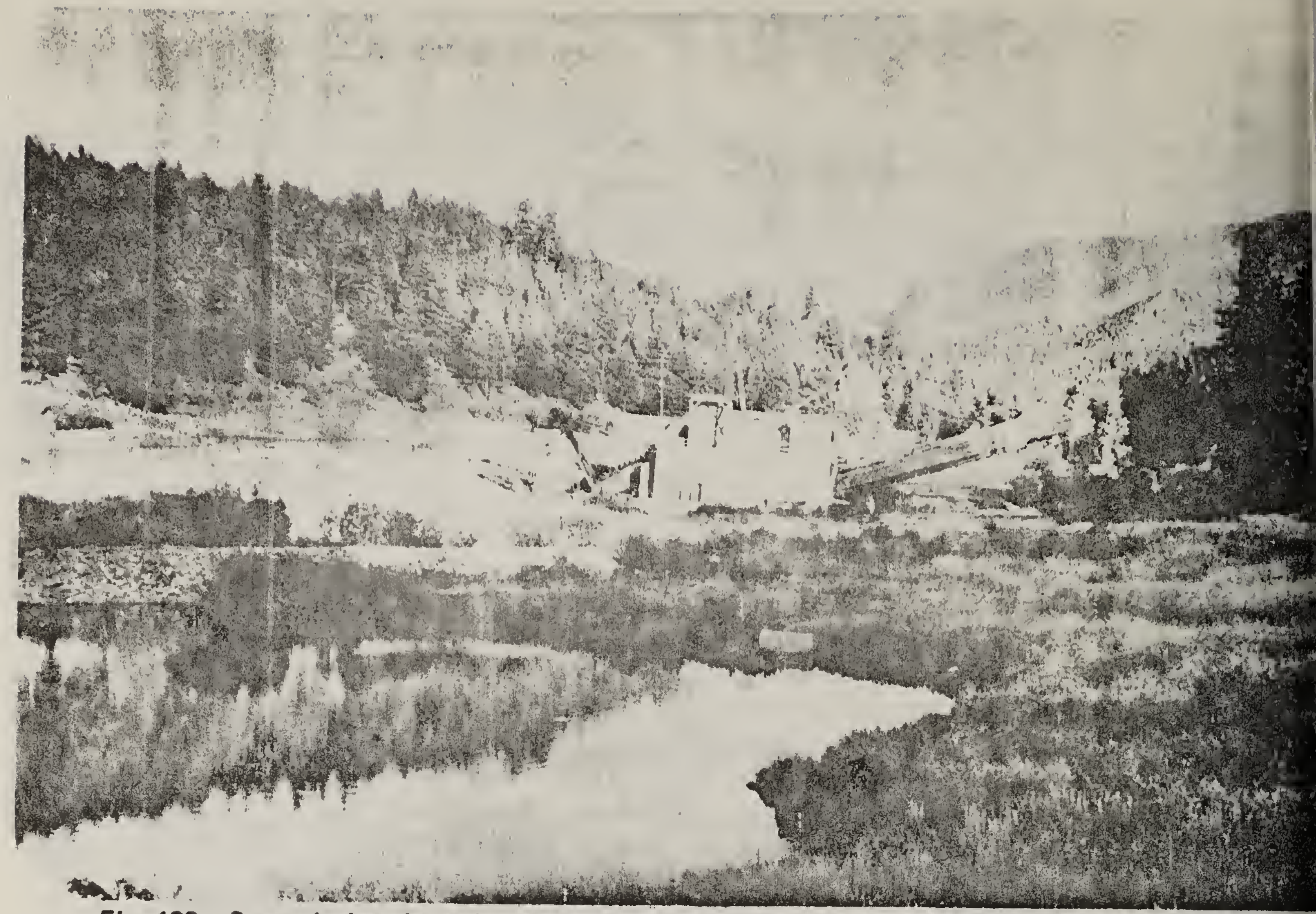


Fig. 133 - Presently inactive gold dredge along U.S. Route 91 south of Helena, Montana. The ponds created by the mining operation currently are used for sport fishing by area residents, several of whom may be seen in the vicinity of the dredge. Bodies of water created by mining operations are frequently used for recreational purposes throughout the West. In the background is a portion of the Deerlodge National Forest.

Washington, where the water table is relatively close to the surface, this has been done with a minimum of effort and cost because the original mining bore the cost of excavation. Thus, abandoned mining operations have specifically *enhanced* the recreational use of the same areas of land involved in the mining operations. Most utilization of such construction material deposits is relatively short-lived, and as a result, the relatively short span of time in which mineral utilization was conducted has resulted in a much longer-term enhancement of recreational facilities.

Throughout most of the Pacific Coast States, the similar enhancement of the land for recreational purposes or the direct utilization of mineral deposits for recreational purposes has resulted in a relatively intense recreational use in terms of persons per acre, just as the mining operations themselves were and are perhaps the most intense use of the land in strictly economic terms. Contrasted with the single mining claim of 20 acres used as a tourist attraction by the Prineville, Oregon, Chamber of Commerce, recreational areas in the rest of the state total more than 1.6 million acres. These include 160,770 acres in two areas administered by the National Park Service and another 762,285 acres in specific recreation areas administered by the United States Forest Service. Included in these latter are 754,226 acres in 10 wilderness or wild areas. The state also has 250 acres in 25 developed picnic and camp grounds administered bysthe Bureau of Land Management, more than 180,000 acres in 18 land and water recreation areas administered by the Bureau of Reclamation, almost 60,000 acres in eight land and water recreation areas administered by the Corps of Engineers or assigned by the Corps to other federal, state, county, or city authorities, and over 440,000 acres included in wildlife refuges administered by the Bureau of Sports Fisheries and Wildlife.[94]

The 20 acre *recreational mining claim* maintained at Prineville may also be compared with the total of 151,558 acres of recreational land maintained by the State of Oregon and by various counties, cities, and private agencies throughout the state. These include more than 60,000 acres in 180 developed state parks and roadside rest areas, over 73,000 acres in 16 wildlife management areas operated by the State Game Commission, some 7,000 acres in 110 county parks throughout the state, slightly more than 7,000 acres in nine city parks, 137 acres included in 21 camping and picnic sites provided by commercial timber companies, and the additional acreage involved in 11 camping and picnic sites maintained by power companies operating in Oregon. In providing recreational facilities for a growing population, the 20-acre claim maintained by the Chamber of Commerce in Prineville undoubtedly creates a far more intensive use of the land for recreational purposes than almost any other use outside of that devoted specifically to developed campgrounds and picnic areas. Certainly the least intensive use of the land for recreational purposes (in terms of the number of people able to use that land per acre) in the state of Oregon would be the 754,226 acres contained in the 10 primitive, wilderness, and wild areas maintained by the Forest Service.

In the Mountain States, existing and past mining areas are also important in the recreational use of the land. At Butte, Montana, the World Museum of Mining is now one of the city's primary tourist attractions, as is a viewpoint overlooking the vast Berkeley Pit operated by the Anaconda Company. At Helena, the state capital, past and present mineral resources are also a means of recreational use. Areas and facilities developed in the gold rush days of the 1860's are now used as tourist attractions, and a folder published by a local tourist promotion agency lists mineral deposits where tourists may dig for sapphires (for a fee), thus making commercial mineral resource utilization and recreation activity one and the same.

In the Little Rockies of Montana, the Bureau of Land Management has acknowledged that remnants of the mining activity conducted in bygone eras make the region a fascinating place for those interested in history, as well as those simply interested in sightseeing. The area abounds in game, including antelope, grouse, and deer, making the Little Rockies also attractive for sportsmen interested in hunting and fishing. With many established camp sites and picnic areas as well as spectacular scenery, the Little Rockies of Montana have become a significant public land area used for recreational purposes. Despite its many natural attractions, the Bureau of Land Management itself has noted that "The greatest attraction for most visitors to the Little Rockies seems to be the weathered buildings and open pits where scores of hard-bitten miners labored over picks, shovels, shakers, and vats to extract that precious yellow metal. These were men who took their recreation indoors in the saloons and gambling halls of Zortman and Landusky—two former gold camps that are now being rediscovered by increasing numbers of those who prefer the outdoor way of life."[95] The same issue of the Bureau of Land Management's magazine describing Montana's Little Rockies noted the recreational values of spelunking (the exploration of natural underground excavations) in New Mexico and the recreational opportunities afforded by the collection of fossils from various deposits of sedimentary rock that exist throughout the Western United States.

The National Park Service has also officially recognized the value of mineral resources (including fossils) for recreational and educational purposes in its establishment of Dinosaur National Monument in Eastern Utah and Colorado and the Petrified Forest National Park in Northern Arizona. At these two sites, mineral resources are the chief attraction for tourists and the principal reason for the existence of the Park Service facility. Similarly, many geologically unique areas throughout the Western United States have been designated by the National Park Service (and, to a limited extent, by the Forest Service) as visitor attractions for recreational and educational purposes.

As in Montana and Colorado, rockhounding and prospecting areas in Idaho are listed as tourist attractions on the recreation map for the state published by the Bureau of Land Management. Ghost towns are also presented in a recreation directory and a map published by the Idaho Historical Society. In Colorado, towns such as Cripple Creek, Leadville, and

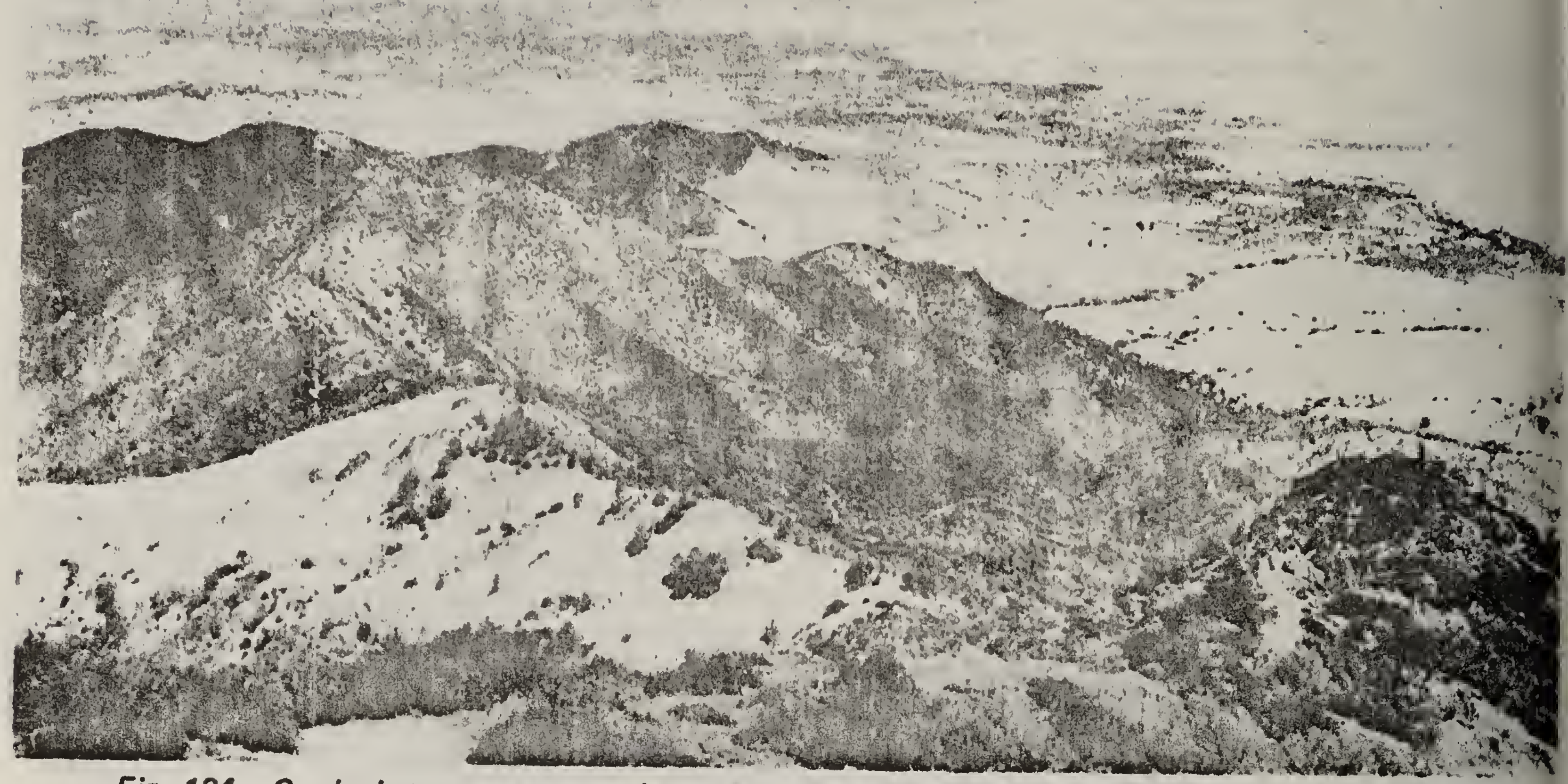


Fig. 134 - Crushed stone quarry on the northern edge of Mt. Diablo State Park, a popular recreation area near Walnut Creek in Contra Costa County, California. View is from the summit of Mt. Diablo. The mining operation is not visible from the principal public recreation areas of the park.

others are today capitalizing on the recreational potential of mining activity, both past and present. In Arizona, one of the state's significant tourist attractions noted in the tourist promotion magazine, *Arizona Highways,* published by the Arizona State Highway Department, is a perlite bed near Superior, Arizona, where semiprecious stones known as *Apache Tears* may be collected by interested rockhounds.[96] This perlite deposit thus serves as a significant recreational use of the land at the same time that it is used commercially as a source of industrial minerals for construction needs in the nearby Phoenix Metropolitan Area. In this case, the same mineral resource on the same land is used for both commercial mineral activity and recreational purposes. This is not a unique situation.

Mineral resources and activities utilizing those resources have become so important in the tourist and recreational activities of the Western United States (and, in fact, of the United States as a whole) that the Bureau of Mines of the United States Department of the Interior published in 1967 a *Visitors' Guide to Mining and Mineral Operations in the United States,* listing mineral industry activity open to and interesting to visitors. The directory lists significant mineral tourist attractions in virtually all of the 50 states, including mines that can be seen from highways, mines that can be visited, ghost towns, historical sites, and mineral or mining museums. The directory covers some 80 pages and, despite this, is relatively incomplete.

It has become a fact that mineral industry activity and recreational activity on the public lands are not necessarily in conflict. In truth, the instances in which *bona fide* mineral industry activity and recreational use of the public lands have been in conflict are relatively slight. In many more instances, mineral industry activity on the public lands has enhanced or created recreational uses of the land. In many other instances, mineral industry activity and recreational use are synonymous. In most areas where there has been a real

Fig. 135 - Recreation area near Mt. Shuksan in the Mount Baker National Forest about 20 miles west of the North Cascades Primitive Area in Washington. The development of recreational facilities in the area has resulted in considerable surface disturbance. The remains of past mining activities in the region are hardly noticeable.

conflict between recreational uses and alleged mineral resource use, the conflict has been caused by those who would abuse the provisions of the mining laws. Such abuse often has involved fraudulent attempts to use the mining laws to obtain public land for non-mining purposes, and this has been the principal cause of most conflicts between apparent mineral industry activity and recreational uses of the public lands. Attempts by over-zealous public land administrators and others who would exclude any activity by man have also caused conflicts. But these have been between *users* of the land, rather than *uses*. Where mineral industry activity has been *bona fide* and of good intent, there has usually been, on the contrary, a greater enhancement of recreational use of the same or adjacent public lands.

F. MINERALS AND URBAN LAND USES

Undoubtedly the fastest growing area of real and potential conflict between mineral resource use and other uses of the land involves urban (residential, commercial, and industrial) uses of the land. The problems have become particularly acute in and around major metropolitan areas. Nevertheless, a survey of large and small mine operators conducted in 1968 disclosed that only four percent of the nation's mining properties were experiencing significant problems of conflict with residential use of the land. Only two percent reported any conflict with urban industrial users of the land.

Objections to mining operations by urban land users are many, varied, and vociferous, primarily because of the relatively large number of small and medium-sized operations producing construction materials in and near concentrations of population. The greatest objections, in fact, seem to occur with respect to sand and gravel pits and stone quarries located near highways or in urban centers. Objections by urban land users to mining have resulted in serious restrictions on the use of mineral resources throughout the country.

In New York, the town board of Wheatfield authorized the town attorney to change the zoning ordinance to prohibit quarries. A crushed stone producer had previously requested the right to mine a 400-acre quarry, but the town's ban ended the possibility of using its mineral resources.[97] In Weston, Massachusetts, the Massachusetts Broken Stone Company is the community's largest industry and its second largest taxpayer. Nevertheless, the company was recently forced to close two aggregate plants and an asphalt plant and was not permitted to quarry due to a zoning law that for many years had been unenforced. This action was brought about despite the fact that the area involved is basically isolated, surrounded by land undesirable for residential use, and despite a $6,000 expenditure for screening the plant entrance, rerouting of traffic from residential areas, and the construction of a dike along one side of the property to prevent the public from viewing the operations.[98]

In the West, there has been a somewhat greater recognition on the part of urban land users of the need for construction materials. In Los Angeles, city and county planners have regarded sand and gravel mining as necessary for urban development and have cooperated with producers in achieving phased land use, with mining followed by other uses. In planning such phased use of the land, potentially useful sand and gravel deposits have been protected from residential and commercial structures in various ways depending upon the particular circumstances involved. Provisions for the control of noise, vibration, dust, hours of operation, access to off-street parking, fencing and screening, setbacks, and other environmental factors are included in the planning and zoning work.[99]

The City of Los Angeles has established trust funds for the specific purpose of acquiring pit sites after mining has ceased. In 1968, the City was using 32 such sites for sanitary land fill operations. Of these, five were owned by the City and five by the County of Los Angeles. The remainder were still owned by private landowners and leased for land fill purposes. Filled pits have been converted to a variety of uses, including golf courses, parks, and industrial sites.[100]

The profit potential for private landowners in the conversion of mined-out construction materials deposits to other uses has been a significant factor in stimulating such conversion. In truth, private gain has probably been the most common and certainly the most effective incentive in the utilization of land for urban uses once mining operations have ceased. This has also been true with respect to post-mining, agricultural, forest, and recreational land use.

Metallic and industrial minerals mines located away from the metropolitan areas present a different aspect of the relationships between mineral and urban land uses. Even in many non-metropolitan parts of the West, however, there are significant differences in the relationship of mining to urban activity. Most of the differences depend on which came first, the mine or the community, and upon the significance of the mineral industries in the local economy.

Fig. 136 - In the 1800's the structure of the mine surface plant were often the most substantial, best maintained, and most aesthetically pleasing buildings in the community. Residential and commercial structures were often thrown together hurriedly and in haphazard fashion as close to the mine site as possible.

There are numerous examples throughout the West (and elsewhere as well) of communities and urban centers that owe their very existence to mineral resources. In Arizona, the towns of Ajo, Bisbee, Douglas, Miami, Morenci, Bagdad, Kearny, Hayden, and San Manuel are almost entirely dependent upon the mineral industries. The same is true of Carlsbad, Grants, Hurley, and Tyrone in New Mexico, of Moab and Lark in Utah, of Ely, McGill, and Yerington in Nevada, of Butte in Montana, of the cities of the Coeur d'Alene in Idaho, and of many others throughout the 11 Western States. Even a number of metropolitan areas are strongly influenced by mineral resource utilization (in addition to sand and gravel production). These include Salt Lake City, Utah; Tucson, Arizona; Spokane, Washington; and a number of others.

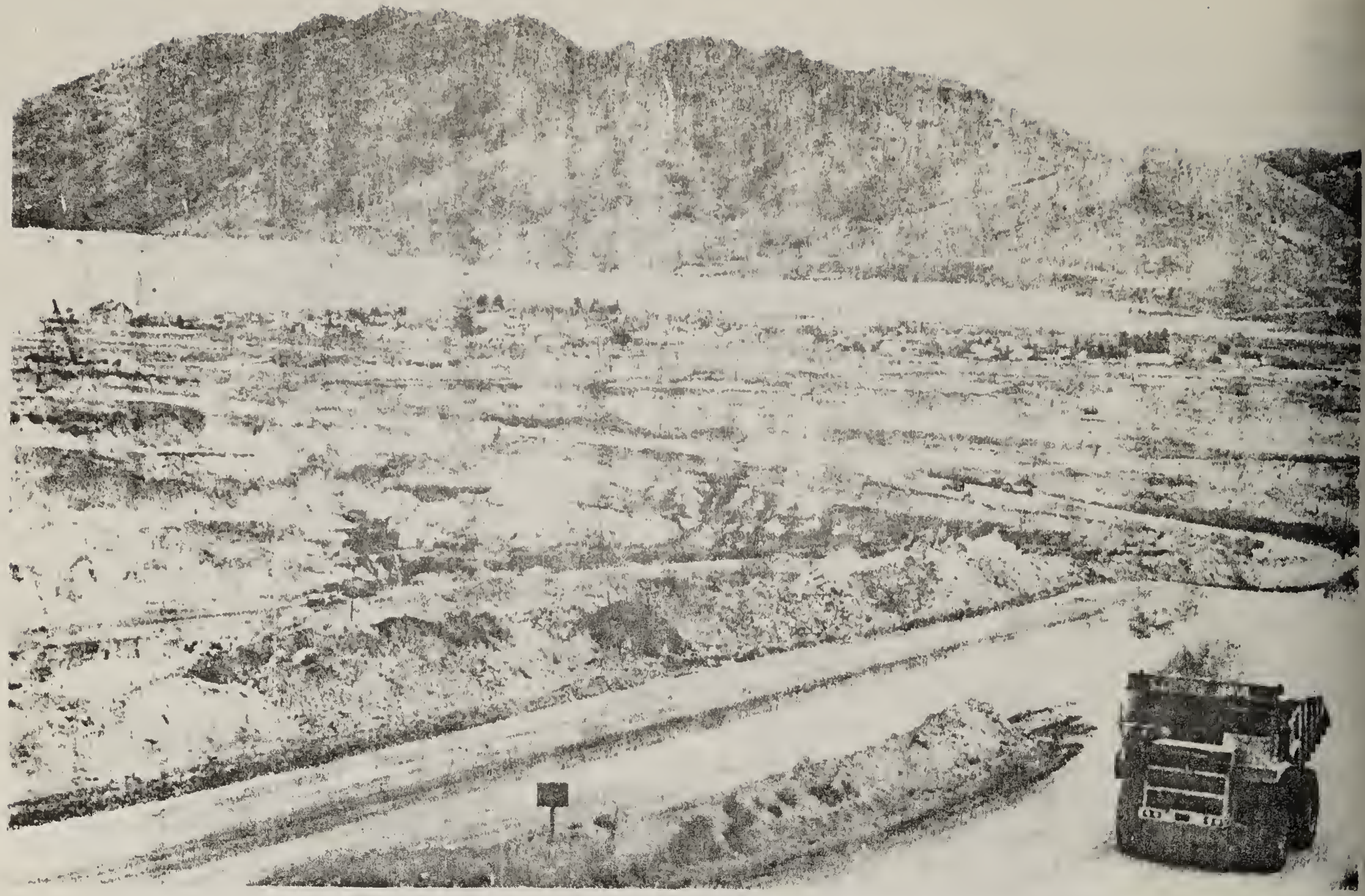


Fig. 137 - Surface mining areas and waste dumps adjacent to residential areas at Butte, Montana. Placement of residential areas as close as possible to mine sites in past years has led to conflicting land use problems when former underground mines have been converted to open pit or caving operations. In some areas entire towns have been moved to allow for expanded mining operations. Finding suitable sites for mine waste dumps has often been a severe problem.

In almost all such areas, solid wastes from mining are stored as efficiently as possible with little or no attention given to camouflaging the operation or restoring the surface to make it appear to be other than what it is. Many of these communities serve as a strong illustration of the old adage that "beauty is in the eye of the beholder." Many people who gain their livelihood from the mines do not necessarily find the mines unsightly, but often recognize the beauty in the color and symmetry of industrial activity. On the other hand, when mining is attempted in an urban area where the people are not familiar with mining and their livelihoods are not directly dependent upon it, there is a much different story. Local ordinances in such areas may flatly prohibit mining, regulate mining to the extent that it may not be feasible, or require concerted attention to the problems of environmental effects.

Many mining operations near urban communities are outside the jurisdiction of the people living there. Nevertheless, a growing number of mining operations have voluntarily accepted the responsibility to maintain the quality of the environment. When the restoration of lands affected by mining can be done in a reasonable way and when it can be included in mine planning, the costs of such restoration are usually minimized and the benefits maximized. In some instances, the reclaimed lands become more valuable than adjoining unmined lands. In others, the reclaimed land has provided profitable side ventures for the mining operators. In the East, the Peabody Coal Company has a program called "Operation Green Earth" which includes planting four million trees each year and developing new forests, lakes, wildlife areas, grazing lands, recreation areas and homesite. In the West, a monumental task of landscaping tailings dams and waste dumps near the

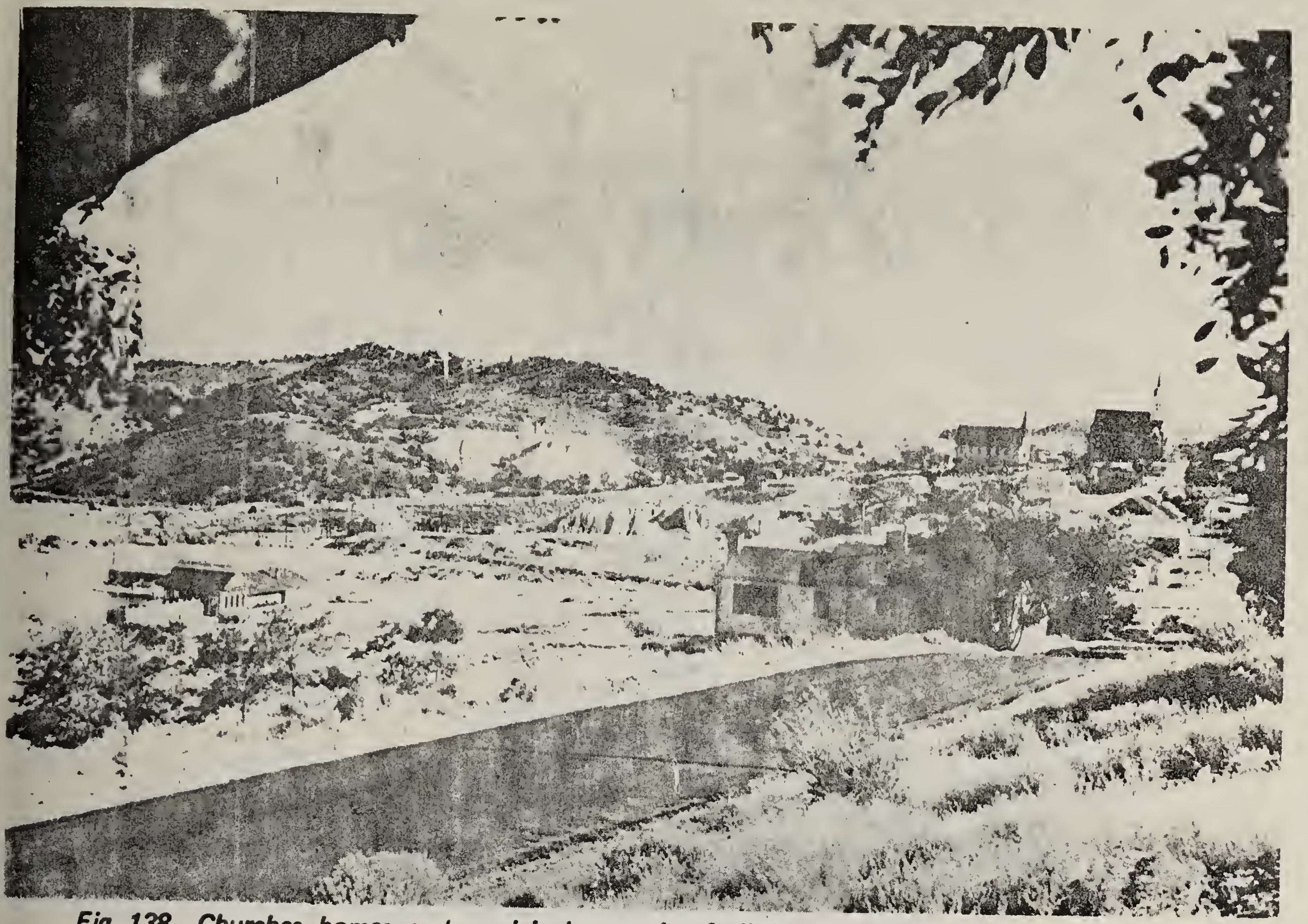


Fig. 138 - Churches, homes, and municipal recreation facilities, including a swimming pool, have been built on the level land provided by former mine waste dumps at Virginia City, Nevada.

retirement community of Green Valley, Arizona, is being undertaken by the Anaconda Company at its Twin Buttes operation. Approximately 12 miles of dikes are being built from waste provided by stripping. Anaconda has a regular nursery program to test and develop native plant species adaptable to the environment. The company has incurred heavy expenditures in landscaping the dikes with grass and desert shrubs that will blend with the surrounding terrain. Healthy specimens of barrel cactus and saguaro that would ordinarily be destroyed by mining are transplanted on the terraced dikes. To encourage the growth of transplanted cacti, shrubs, and seeded grasses, the top layer of alluvial soil is mixed with organic fertilizer and heavily watered until the roots of the grasses are well established. For watering, the company has constructed over 20,000 feet of 6- and 8-inch irrigation pipe and movable sprinklers.[101]

Despite much efforts, many persons in the nearby community complain of the unsightliness of the mine, even though the tailings dams cannot be seen from most of the town's residential areas. The problem of urban psychology probably has been the greatest single factor in the relationships between mineral resource utilization and urban land use. The same is true with the relationships between mineral resources and virtually all other uses of the public lands. Most conflicts have been more imagined than real and between *users* rather than *uses* of the land.

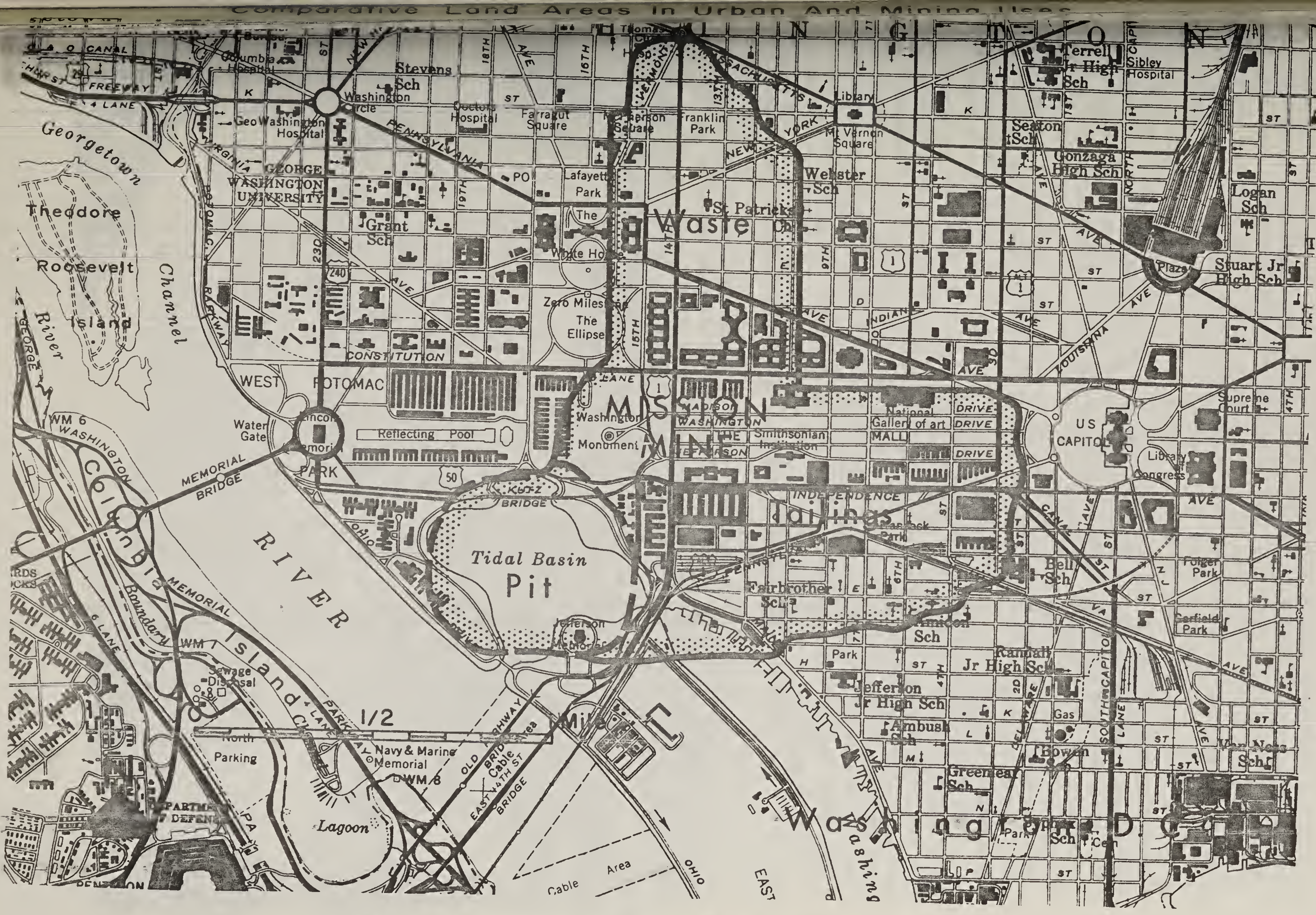


Fig. 139 - The Mission Mine of the American Smelting and Refining Company near Tucson, Arizona, is a moderately large open pit copper mine, producing approximately 20,000 tons of copper ore per day. If the deposit had beeen in an urban area, serious land use conflicts could have developed and might have prevented development of the mine.

Comparative Land Areas In Urban And Mining Uses

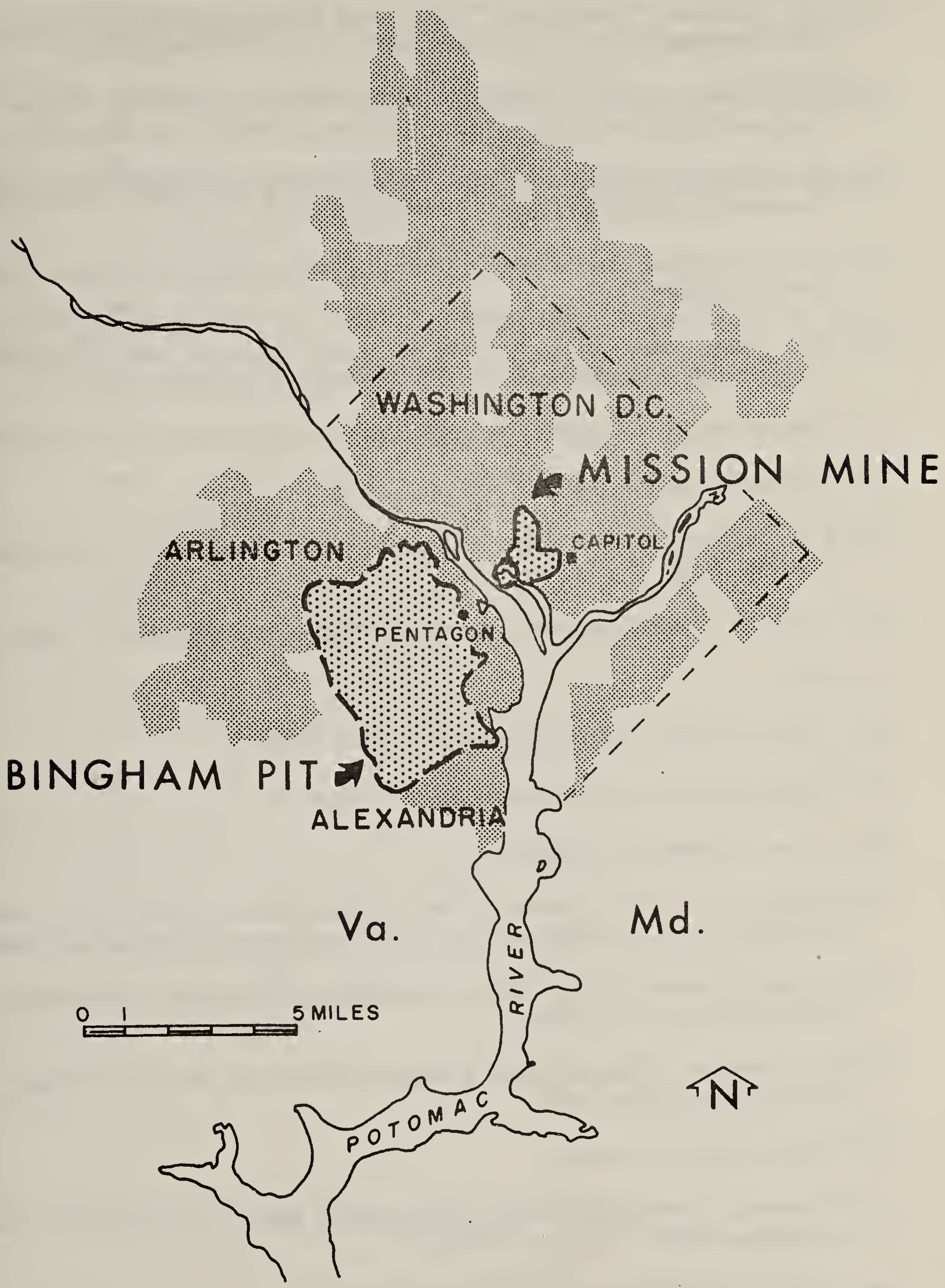


Fig. 140 - The Bingham Pit of the Kennecott Copper Corporation, near Salt Lake City, if superimposed on a major metropolitan area would have serious land use conflicts. The pit alone is almost as large as Alexandria County, Virginia. Waste and tailings storage areas require additional areas. The development of the Bingham Pit to its present status as the largest mine in the United States did require the destruction of the community of Bingham Canyon, Utah, as well as other nearby commercial and residential land uses.

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NONFUEL MINERAL RESOURCES
AND THE
PUBLIC LANDS

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MINERAL LAND SYSTEMS

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Prepared for
The United States Public Land Law Review Commission

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CHAPTER 15

NON-PUBLIC LAND SYSTEMS

Have the various non-federal systems of mineral land acquisition and tenure used in the United States had measurable effects upon the utilization of nonfuel mineral resources?

A. STATE MINERAL LAND SYSTEMS

1. General System Features

The 13 original United States developed state land policies that reflected both their individual sovereignties and origins as crown colonies. As the nation expanded westward, however, the mineral land policies and procedures devised by the newer states reflected the additional effects of federal policies and practices in making public land available both for mineral purposes and for other uses. In many cases, restrictions were imposed upon lands ceded to the states by the federal government which prevented the sale of such lands by the states without the retention of mineral rights under state government ownership. In other instances, there were no such restrictions.

Regardless of origin or influence, throughout almost the entire United States, policies regarding the disposal of mineral properties owned by the states have been developed. In the original 13 states, public land policies with respect to minerals largely reflected the colonial charters issued by the King of England, which reserved interest in specific minerals to the Crown. Ownership of minerals that were not specifically reserved, however, passed to the owner of the surface rights, be it the state or the private individual. After the American Revolution, however, the practice of explicitly reserving minerals to the state fell into relative disuse.

Over the past two centuries the development of state mineral disposal policies and the enactment of legislation related to those policies have been influenced by the presence within many states of federal public land. In other states, the very lack of public domain has had its effects. The states can presently be grouped roughly according to the influence that federal public land policies have had on state mineral land disposals systems. In the first group may be included all states in which the federal government has virtually no public domain and in which the federal mining laws have never been generally applicable. This group includes the original 13 states and other states that were specifically created from the territories that belonged to the 13 original states, as well as other states which originally had sovereign power over public lands within their borders. The original 13 states include Massachusetts, New Hampshire, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia, while those states created specifically from territories from the original 13 are Maine, Vermont, West Virginia, Kentucky, and Tennessee. Also included in this group are those states (Texas and Hawaii) which had sovereignty over their own public lands as independent nations before admission to the Union.

The second major group includes those 11 Western States and Alaska that were carved from public domain and still retain large areas of federally owned lands. These include, in addition to Alaska, the three Pacific Coast States, California, Oregon, and Washington, and the eight Mountain States, Montana, Idaho, Wyoming, Utah, Nevada, Colorado, New Mexico, and Arizona. The third group consists of all the other United States that are neither public land states nor completely non-public land states as are the first 13 and their associated territories. This last group includes virtually all of the Plains, the Midwest, and much of the South. There are certain differences prevalent in the state mineral disposal systems of each of these groups.

To date, all but six states (Connecticut, Massachusetts, New Jersey, Kentucky, Ohio, and Iowa) have enacted legislation providing for the leasing of state-owned mineral lands or mineral rights that had been reserved to the state after the sale of other state lands. Four states (Rhode Island, Vriginia, West Virginia, and Tennessee) have laws that mention the leasing of minerals from state-owned lands but make no general or specific provisions for such activity. Two states (Delaware and Ohio) provide only for the leasing of oil and gas, while one state (Maine) provides only for the leasing of so-called *hard* minerals. Nevada, on the other hand, provides for the leasing of all of the fuel minerals, coal, oil, gas, and oil shale. Virtually all of the other states have relatively complete legislative programs covering the disposal (usually by leasing) of all minerals that are the property of the state.[1]

In the various state programs concerning the disposal of state-owned mineral lands or rights, there are usually distinctions between mineral commodities. As a rule, there is at least a distinction between oil and gas and all other minerals. In some states, sulfur and minerals produced from brines are considered as a third category, while in other states they are classified with oil and gas. In some states, the industrial minerals commonly used in construction and which are of fairly widespread occurrence (e.g., sand, gravel, clay, and stone) are also included as a separate category. Where there is some particular local circumstance that gives a particular mineral local prominence, such a mineral has often received separate legislative attention. As a result, the various state mineral disposal systems vary widely in their treatment of the different mineral commodities. Most of the state statutes governing oil and gas disposal are relatively consistent, with little variation from one state to another. The wide variation in state mineral land disposal systems comes in their treatment of the nonfuel minerals.

In many of the United States there are distinctions between the policies that provide for access to state mineral lands for exploration purposes and those policies governing the production of minerals from state lands. Many states allow free access to state-owned land for the purpose of minerals exploration. Such has been the basic policy established in New York, Colorado, Idaho, Nevada, Oregon, and Alaska. In a number of states, however, access to state lands for such purposes is not completely free. In some instances, particular state lands have been withdrawn completely from mineral exploration and utilization, while in others, prospecting permits are required for the conduct of minerals exploration on most state-owned lands. In many states, including Maine, New Hampshire, Minnesota, Wisconsin, Louisiana, Nebraska, Oklahoma, Texas, Montana, Utah, Washington, and California, the right to explore for minerals on state lands can be obtained only by applying for a prospecting permit from the state government. In a few states (Idaho and Arizona), the use of a prospecting permit is not required in all cases.[2]

There is considerable variation among states even where prospecting permits are used. In some states, prospecting permits may be used on some lands, but they are not applicable to others, including lands that are subject to direct mineral leasing. In some states, certain minerals may be excluded from the jurisdiction of any individual prospecting permit. In Texas, for example, coal, lignite, potash, shell, sand, and gravel are excluded from prospecting permits for other minerals. In Maine, sand and gravel are also excluded from prospecting permit provisions, and in Montana, all nonmetallics are excluded. In fact, virtually all state prospecting permits vary with respect to the specific minerals to which they apply.

State land prospecting permits also vary according to the time intervals for which they are effective and in the specific rights and benefits which they impart to the holder of such a permit. Many prospecting permits are granted for a one-year term. This is true in Alaska, Maine, Utah, and Oklahoma. Others are granted for two-year periods as they are in Idaho, Minnesota, and Washington. In some places, the prospecting permit is effective for a much longer period. In Texas, the term is five years. Provisions for the extension of a prospecting permit are also variable. In Alaska, the term of a prospecting permit may be extended, depending upon the particular circumstances involved. In Montana and Utah, one-year extensions may be obtained. In Texas, New Mexico, and Washington, however, the extension period for a prospecting permit depends upon the specific mineral being sought.

There are also variations in both the normal and maximum areas covered by a single prospecting permit. In Idaho, the maximum acreage covered under a single permit is 20 acres. This increases to 80 acres in Washington and Minnesota and 160 acres in Alaska, Oklahoma, and Utah. Other states permit larger acreages to come under one permit, while others allow the issuance of contiguous permits to the same individual.

The fees charged for state prospecting permits are also quite variable. In most cases, they are nominal. For example, in Maine the fee is $2.00, while in Montana it is $1.00 per year. In Washington it amounts to $5.00 for every 40 acres, and in Idaho it is $10.00. In states where the fee increases above the nominal rate, the fee is usually related directly to the acreage involved in the permit.

In virtually all of the states that provide for prospecting permits in their mineral disposal systems, there is a specific work requirement included in the provisions of the permit. This is usually stated in terms of a given dollar value of work that must be performed, and this in turn is usually related to the size of the area covered by the permit. For example, in Alaska there is a $5.00 per acre work requirement for the first year of the permit, which rises to $10.00 per acre per year for each year thereafter. In a few states (such as Montana), however, it is simply necessary that the holder of a prospecting permit pursue diligently his exploration work within the time period allotted. Of course, failure to do so in most cases has an adverse effect upon the renewal of the permit.

In most cases, prospecting permits are issued for state lands on a first-come, first-served basis. In Minnesota, however, permits are issued on a competitive bid basis in those areas considered to have known deposits of commercial iron ores. The basis for the bidding on the prospecting permit is the amount of royalty to be paid under an iron ore mining lease, and assumes that a discovery of a workable mineral deposit would be made. These arrangements in Minnesota have had serious adverse effects upon exploration for copper and nickel in recent years. In other states, a required waiting period between application and issuance of a prospecting permit has allowed previously unknown prior claimants to mysteriously appear. Chicanery in the operation of state systems has not been rare.

In addition to the exclusive exploration rights granted under a prospecting permit, in many states such a permit provides its holder with a preferential right to a lease or mineral claim upon discovery of a valuable mineral deposit within the area covered by the prospecting permit. In a number of states, the preferential right lease is mixed with a combination of competitive bidding leases that in some instances becomes rather complex.

Various states, particularly in the West, also provide for the location of mining claims upon state lands. These are not claims in the same sense as the term is used in the federal land system, however. Mining claims under most state procedures are of one or another of three types. Two of these types provide (for a fee) an actual right to extract minerals from state lands for sale or use. The third type is really only a development claim which allows the discoverer of a mineral deposit to develop his property prior to mining it under a subsequent lease arrangement. In Alaska and New York, the state mining claim that is issued as a result of the discovery and physical location of a mineral deposit is somewhat similar to the mining claim located under the federal mining laws on National Forest lands. In effect, however, in both these states the so-called mineral claim is in reality an indefinite term mineral lease. Since all mineral rights on state lands in these states are reserved to the state, a royalty as well as a rental are charged for removal of those minerals. The so-called claims, or open-ended leases, may run indefinitely as long as a specific amount of development work is performed each year. Rentals and royalties only begin upon the initiation of actual mineral production.

The second type of so-called mining claim made on state lands results from a discovery established under the provisions of a prospecting permit that has previously been issued. This claim is also in reality a mineral lease, and may likewise be of an indefinite term, continuing so long as specified work requirements are performed. Such a mineral claim may include all minerals, as in New Hampshire, or only a specified mineral, as in many other states. This type of so-called claim (or specific area lease) also provides for royalties and rentals. In many cases, these royalties and rentals are established by statute. In other states they are negotiated, with minimum figures established by state law. In a few states, they are completely negotiated.

The third type of claim that can be filed on state lands simply provides a period of time which is relatively short within which a lease may be obtained, in effect providing some post-discovery, pre-production protection to the claimant. The claim does not grant any rights to the minerals on the land until the appropriated lease is issued by the state, nor does it permit any mining under the claim except for development purposes. In some states, such as Oregon, the location of claim is not necessary prior to obtaining a mineral lease on a specific area of state land.

Although there are some significant legal differences between these three types of mineral claims (as they have been defined from one state to another), in effect they all provide a means by which an area to be included under a state mineral lease is specified (on the ground and in legal records) by the person who wishes to utilize the minerals that he has found on state lands. They are simply, then, a means of designating the area to be included within the state mineral lease.

In most states, mineral leases can be issued on a noncompetitive basis, either upon immediate application to the state (as in Idaho and New Mexico), after a discovery (as in Texas), or as a result of a preferential right established under a prospecting permit or a mining claim. In a very few states, mineral leases are granted competitively to the successful bidder, even though these lands may have been previously included within a prospecting permit area.

Many states include in their mineral leases a provision regarding the initiation of production within a specific time, as well as the performance of a specific amount of annual work. Some states, namely Pennsylvania, Vermont, Virginia, Indiana, Oklahoma, North Dakota, Montana, New Mexico, and Wyoming, require a performance bond in initiating development and production on a state mineral lease.

The time periods involved in state mineral leases are quire variable. In most instances they are specifically established by law. In virtually all states they may be terminated upon 30 days' notice if there has been failure to perform under the lease. In a few instances, authority has been given to state land boards or other state authorities for the determination of lease periods. Actual periods involved in state mineral land leases range from one year (for sand and gravel in Idaho) to 55 years in Alaska, and 50 years (for all minerals expcet iron ore) in Washington. The term of most, however, ranges between 10 and 20 years. State mineral leases frequently have five year increments which are renewable.

The rentals charged for state minerals lands are also variable. In many instances, rentals are subject to determination by appropriate state boards or commissions. In other instances, mineral land rentals are fixed by statute. In still other states, a statutory minimum is established, with any rental above the statutory minimum determined by negotiation. In a few instances, such as in Alaska, the rental charged is on a per lease basis. In most states, however, there is a definite relationship established between the rental charged and the acreage involved. In Maine, for example, the annual rental is $5 per acre, while in Nevada it is $1 per acre. In Idaho the mineral land rental is 25 cents per acre per year. In many states there are also sliding scale provisions with minimum rentals charged during the first year of a mineral lease and increasing amounts charged during subsequent lease periods. In New Mexico, for example (for all minerals except fertilizer minerals, coal, lignite, sand, and gravel), the minimum rental is five cents per acre per year for the first two years of a lease and 50 cents per acre per year for subsequent years of the lease. In some states rental payments are required throughout the entire life of the lease, but in other states, rental payments may cease when royalty payments from the production begin or exceed the rental figure.

In only a few states (such as Alaska) are there no royalty payment requirements made for a mineral lease in addition to the basic land rental. In most states, however, there is a royalty requirement. The amount of royalty may be prescribed by statute, established by a state land board or other responsible state executive authority, or determined by negotiation.

In some instances, royalties under state mineral land leasing systems are based on the quality or grade of the mineral commodity produced. This is true with respect to Idaho phosphate leases, Minnesota iron ore leases, and South Dakota uranium leases. In some other states, royalty rates are based on a volumetric measure. This practice is widespread with respect to sand and gravel leases where rates per cubic yard are common. In many states, royalty rates are based on a weight measure. This is normally the case where coal is mined under state mineral leases. For most nonfuel minerals, however, state royalty rates are based on a percentage of the value of the minerals produced. The royalty rate may vary according to the specific minerals mined, as is the case in Montana and New Mexico, or it may vary according to the area within the state in which mining is conducted. This is the case in New Mexico. The royalty may be fixed or it may be expressed as a range of percentages, as is the case in Idaho and Washington.

The maximum number of acres permitted in state mineral land leases varies considerably from one state to another. In many states, although state mineral land leases are based on a maximum mining claim size that in most cases approximates 20 acres, leases containing multiples of claims are permitted. In other states there is a straight acreage limitation placed on any one mineral lease. In Alaska the limitation is as low as 40 acres. In Montana and Washington (for coal) the maximum is 640 acres, or one public land survey section. In Utah the maximum is 2,560 acres. In Minnesota the maximum is 80 acres. In a few states, such as New Hampshire and Montana, the lease acreage depends upon the size of the deposit. In New Hampshire the maximum acreage is specified as that which is sufficient to cover all or a portion of the mineral deposit involved. In Montana, the maximum lease size for metalliferous minerals is set at the area considered mineable. In virtually all states that have mineral leasing systems, the surface area included under a single lease does not give extralateral rights to additional areas below the surface. The major exception to this is Arizona where there are provisions for extralateral rights on lode claim mineral leases. In only a very few states are there any distinctions between lode and placer claims or leases.

In almost all states, the patenting of claims on state lands is not permitted. In those few states, such as Nevada, where patenting is permitted (at least in name), a perpetual royalty requirement is attached to the patent, so that in effect an infinite term lease is issued. In one state (Minnesota), the right of eminent domain can be exercised to subordinate a surface owner's rights to that of the possessor of the mineral rights if the exercise of those mineral rights are considered sufficiently important to the general welfare. In virtually all states in which policies and procedures have been established for the utilization of minerals on state lands, environmental control provisions have been included in lease agreements. Some of these have been relatively specific, while others have been comparatively vague.

The effects of state mineral land systems on mineral resource utilization have been, like their numerous provisions, quite variable. In some states, they have apparently discouraged nonfuel mineral development, while in others they have encouraged it. The net effects, however, have been difficult to quantify, and no real conclusions can be reached regarding their relative impact as a whole. The development or lack of development of mineral resources on state lands in each of the 50 United States has been the result of combinations of geologic, technical, and economic factors as well as the existence and nature of private and federal land systems existing side by side (in many instances) with the state land systems. The net effect of any state land system has always been the result of its relationship to the features of other systems on lands also available to the potential minerals producer.

2. State Mineral Land Systems in the East

The state mineral land systems that have developed in the states east of the Rockies have reflected the relatively small amount of federal public domain in those states, as well as the relatively high proportion of privately held land. In addition, the dominance of the fuel minerals, primarily coal and oil, has had an obvious influence on most state land systems outside of the Western States. Since World War II, general public interest in uranium has also left its mark. Mineral resource concepts dating from colonial days have also had their influence.

The State of *New York* permits mineral claims to be filed for gold and silver on privately owned land and for any mineral on state-owned lands, but there is no patenting of mineral claims allowed in the state of New York. There are no maximum or minimum acreages involved in these filings. There is a $50 fee required for registering the notice of a mineral discovery. Upon the filing of a claim, a mining permit or lease can be issued by the State for the removal of mineral materials. The specific terms of such leases are determined by the appropriate state authority. Every mineral lease terminates within 30 months from the date of issue unless $250 has been expended on exploration or development for each 40 acres included within the permit or lease for each of the first two years on the 30-month period. If that much has been spent on the property, then the permit or lease may be continued for an additional 30 months on the same basis, plus the payment of royalties if any become due. State mineral royalties are set at two percent of the market value of minerals produced from state-owned lands.

For gold or silver deposits on privately owned lands in New York, there is no royalty required for the first five years, but thereafter the royalty is set at one percent of the market value of the minerals produced. For sand and gravel deposits on state lands, production is allowed under a license from the State. The fees involved in such licenses are variable.[3]

In *Maine* the State holds in trust a large number of scattered areas that are essentially school properties. These, however, are available for prospecting through the Maine Mining Bureau. In most instances, the timber and grass rights on these properties are in private ownership. Included in these areas are about 180,000 acres of school lots which range in size from 120 to 1,000 acres each. In addition, the state has about 1,000 acres of public domain. Other state lands are usually designated for special purposes and have for the most part been withdrawn from mineral exploration or development. Under the mineral land system of Maine, prospecting permits must be secured for mineral exploration on state land. For each permit there is a fee of $2, and the permit is effective from the date of issue until the following December 31st, but may be revoked sooner for cause by the State Mining Bureau.

Any holder of a Maine prospector's permit may stake a mineral claim on available state lands. In unorganized townships, the prospector's permit limits staking to three claims per person per year. In organized towns, there is no limit to the number of claims that may be staked. The maximum dimensions of any one claim are 1,500 feet by 600 feet. Within 30 days of staking a claim the locator must record that claim with the state land agent or forest commissioner in Augusta, the state capital. The recording documentation must include, with the location notice, a drawing designed to show as accurately as possible all physical features which would help locate the claim, as well as information showing the markings on the corner posts and a plot of the claim. Each mineral claim is given a specific number by the state land office, and this number must be attached to all corner posts on the claim itself.

The State of Maine mineral claim can remain in effect from the date of recording until the following December 31st and then may be extended from year to year for four more years. At the end of the maximum five-year period, the claim automatically lapses unless the person owning the claim has applied for and received a license to mine. If a locator allows his claim to lapse, he may again record it after 60 days, if no other person has staked the claim in the meantime. Thus, when a minerals seeker has located and recorded a claim on state mineral lands in Maine, he has at most five years in which to prove the value of the mineral deposit on his claim. During that time, the claim must be worked a minimum of 200 man hours per year, and this work must be such that it can be used to reveal the shape, size, and mineral content of the mineral deposit involved. Before December 31st of each year, the holder of the claim (which is in effect an exploration claim) must file an affidavit describing the work done during the year. Where the claim holder has a group of two or more contiguous claims, he may fulfill his work requirement for all the claims on one or more of the group, so long as the work done equals the total of 200 man-hours multiplied by the number of claims involved.

Even though most state lands in Maine may be open to exploration, all such lands are not available for mineral development, and even though a claim has been filed and recorded, application must subsequently be made to the Mining Bureau of the state for a ruling as to whether mining operations can be undertaken. If the appropriate authority rules that they can, then any person with a recorded claim may apply to the Mining Bureau for a license to mine that claim. The application must be accompanied by a report from a geologist or a mining engineer describing the proposed mining operations, as well as a license fee of $25.00 per claim and an accurate survey of the property boundaries. This license to mine, if issued, remains in force until the following December 31st and may be renewed for each successive year upon payment of the fee of $25.00 per claim. Once a license to mine has been issued, there is no requirement that a specified amount of work be done annually on each claim. There is, however, an annual rental charge on such claims of $5 per acre. If minerals are produced from a claim, a royalty is charged at the rate of five percent of the market value of the minerals produced. If the royalty payments exceed the rental due in any one year, the rental charges are eliminated. The land rental, then, serves as a minimum royalty.

Mining leases are also available in Maine for any holder of a license to mine. These leases are negotiated on an individual basis by the State Mining Bureau, but rental and royalty payments are the same as those required by the license to mine. The Bureau has the right to require one year's operation of a mineral property under a mining license before granting a mining lease. The major difference between a mining license and a mining lease in Maine appears to be the duration. The maximum term of a mining license is one year, but it is renewable, while the mining lease is valid for a longer period of time.[4]

In *Minnesota,* the state has reserved for its own use all the iron, coal, copper, gold, and other valuable minerals located on state lands, as well as on many privately held lands. All persons who hold a state minerals permit or lease are granted the right to prospect upon state-owned lands and also upon those private lands from which the state has reserved mineral rights. When the surface is not owned by the state, the private holder of a mineral permit or lease must negotiate with the surface owner for property damages. If an agreement cannot be reached, condemnation suits against the surface owner may be brought by the holder of the mineral lease desirous of mining the minerals, under the state's privilege of eminent domain.

The Minnesota state mineral land system involves a prospecting permit which is good for one year, but no one person may have a permit two years in succession. Work under a prospecting permit must begin within 90 days after its issuance and continue until the permit expires or a mineral lease is requested. A mining lease may be applied for during the term of a prospecting permit. Prospecting permits and mineral leases both apply to *mining units,* which normally contain 80 acres each, as determined by the appropriate state agency. In some cases, however, a mining unit may be expanded to as much as 90 acres.

It is curious to note that Minnesota makes a distinction between *taconite* and *iron ore.* Actually, of course, taconite is simply one type of iron ore, the distinction between the traditional high-grade ores and taconite being in grade and certain mineralogical characteristics. For *iron ore* leases, there is a rental of $1,250 per mining unit for the first year and $5,000 each year thereafter. If a mineral lease is defined as a *taconite* lease, however, the rental drops to $400 per year for the first year and $1,600 each year thereafter. Leases are awarded on a competitive bid basis with variable royalties determined in the bid for the prospecting permit. Minimum royalties are established by the state. These minima vary, depending upon the grade and other characteristics of the ore mined.

For the removal of "gold, copper, silver, cobalt, coal, graphite, manganese, iron sulfides, other sulfurous ores, titaniferous magnetites, or other valuable minerals" under either a *taconite* lease or an *iron ore* lease, the taconite schedule of royalties and rentals prevails. Nevertheless, a special lease may be granted by the state for one mineral or another, and the leases often are or can be modified to include the particular mineral that is found to exist on the land. Prospecting permits for minerals other than *iron ore* or *taconite* have a duration of two years, and a lease must be obtained within the permit period. The maximum duration of such a lease is 50 years. Under the prospecting permit, work must be begun within six months of the date of issue.

For non-iron ores, the maximum area included under one prospecting permit is a *mining unit* which consists of a maximum of 160 acres. The fee for the prospecting permit is $50. A lease for non-iron minerals applied for under this prospecting permit carries a rent of $500 for each of the first five calendar years and $5,000 per calendar year thereafter. These rentals apply to the entire mining unit.

The state land systems in Minnesota have been heavily influenced by the dominance of iron ore mining in the state's mineral industry. Existing provisions for the disposal of other minerals on state lands are related, and in fact, have evolved from the peculiar circumstances surrounding the development and utilization of iron deposits in Northern Minnesota.[5]

In *New Hampshire* the mining claim that may be filed on state lands is similar to that allowed in many other states. A minerals seeker must first secure a license to prospect upon such state lands as have not been closed to prospecting because of other uses. The prospecting license holder must post a security bond as a guarantee against "unreasonable" damage to state lands. The holder of a license to prospect who discovers a valuable mineral deposit must then file a mining claim with the state forester for all or any part of the deposit that he has discovered as may be allowed by the State Land Commission. The mineral claimant is then permitted to produce minerals from the claim subject to regulation by the State Land Commission and subject to the payment of royalties to be determined by the Commission. The right to the mining claim continues as long as the license holder expends annually at least $100 on the claim in "exploring, testing, assaying, or preparing for mining, and mining."[6]

Mineral claims are allowed in *Pennsylvania* for iron, coal, limestone, sand and gravel, fire clay, and "other minerals." Such claims may not extend over an area greater than 100 acres. In order to utilize mineral resources on state land in Pennsylvania, a minerals warrant must be secured from the state. This warrant has a 10-year term, and involves a variable per acre price as well as a warrant fee of not over $4.50. Ten years after the date of issue of the warrant, a mineral patent may be secured, giving the mineral producer the right to mine the mineral specified in the warrant. There is a $10 fee for patent. This, of course, is not a patent in fee simple but involves the payment of a royalty to the state.[7]

Although the *Republic of Texas* followed Mexican law and tradition in reserving all mineral rights to the sovereign, the *State of Texas* adopted a different policy. Legislation adopted in 1895 leased to the holder of surface rights all minerals contained under their land. The state's mineral law of the same year, however, reserved from sale (except under specified provisions) all public lands held by the state that contained valuable mineral deposits. As might be expected in Texas, primary emphasis in the state's mineral disposal system is placed on oil and gas. Nevertheless, leases may be issued by the state for the production of coal, lignite, sulfur, salt, and potash, as well as petroleum and natural gas. Minerals other than oil and gas may be leased either together or separately. For oil, gas, and sulfur, royalties paid on state mineral land leases are set at no less than one-eighth of gross production. This is a traditional proportion common to oil and gas land systems. For other minerals, the minimum royalty is one-sixteenth of the gross value of production.

Texas authorizes the location of mining claims on certain state lands upon compliance with certain statutory requirements. Oil, gas, coal, and lignite are exempt from mineral claim patenting procedures, however. The patent that can be acquired under the Texas state system resembles somewhat the patent that can be acquired on minerals on National Forest lands, because the surface rights of the claim locator are limited to that part of the surface that is considered strictly necessary for the mining and processing of the minerals contained on the claim. Production from a Texas mineral claim, however, is subject to a perpetual royalty of one-sixteenth of the total value of minerals produced. The claim is thus not really a claim in the same sense as it is on public domain, but is merely an infinite lease of the mineral rights.

The area involved in any mining claim is set at a maximum of 1,500 by 600 feet. Rights under mineral claims are allowed to continue so long as assessment work is accomplished. In addition (for minerals other than sulfur, oil, gas, coal, and lignite), a rental of 50 cents per year and a royalty of 6.25 percent of the total value of production must be paid. At any time after five years from the date of the initial recording of the claim, the claim owner may pay off the balance of $10 per acre (less the previous annual payment of 50 cents per acre per year), and no further assessment work is required. The royalty requirements, however, continues to perpetuity. Even under a mineral claim that has been patented, however, appropriate payments must be made to the state or to the private surface owner for surface damage caused by the claim owner.

Sulfur leases involve a term of 10 years and a royalty of 25 cents per ton. Any 10-year lease may be renewed for another 10 years or less. In addition, annual rental payments of 10 cents per acre for each acre under lease are required.[8]

In *Alabama* there are provisions for the leasing of oil, gas, and other minerals on state lands. The leases are competitive, and there is a $25 filing fee for a drilling permit for each oil and gas well. In addition to this, there is a tax of two percent of the gross value of output at the point of production. For oil and gas leases there is a maximum size of lease of 5,200 acres. Bids are made sealed and the bid is awarded to the highest responsible bidder making the royalty offer considered to be most advantageous to the state. The Alabama system also involves the leasing of state lands for the mining of coal, iron, and other minerals on a royalty basis.[9]

In *Florida*, phosphate deposits and deposits of clay, gravel, shell, and other mineral materials may be leased on state lands or purchased in place. The terms of state mineral land agreements, including royalties, rentals, and all other aspects are not established by statute but are set by the state land board or the particular state institution which has administrative authority over the state land in question.[10]

The state mineral land systems operated by other states east of the principal public domain states cover a similar wide range of provisions regarding the various aspects of mineral resource utilization. In only one respect are they all similar. In each state, the state acts as a landlord and does not relinquish either title or control of the land to private interests. In every other respect, divergence from state to state is the rule.

3. Western State Mineral Land Systems

Mineral rights on state lands in *Arizona* may be obtained by private individuals under a state lode claim system, which is in reality a combination of the traditional location and leasing systems. Under this system, a lode claim of no larger than 1,500 by 600 feet may be located on state lands for which a prospecting permit has first been issued. A state lands prospecting permit is good for five years and requires the payment of a fee of $1 per year per acre. Under the prospecting permit, there is an exploration work requirement of a value of $10 per acre per year for the first two years. This increases to $20 per acre per year during each of the last three years of the permit.

When an individual wishes to conduct a detailed examination or evaluation of a potential mineral deposit discovered under the prospecting permit, he must then stake lode claims, each of which may be no greater than 1,500 feet by 600 feet in extent. No placer claims are allowed on state land in Arizona, and there are no limits to the number of claims that may be staked by one person. These claims may not be patented, however, and both the surface and mineral rights in effect remain the property of the State of Arizona and do not pass to private ownership through the mineral locations procedure. The staking of claims merely establishes the specific areas to be leased for their mineral values. A state mineral lease thus defined runs for 20 years and has a preferred right of renewal, but may be terminated upon 30 days' notice.

Under the state mineral lease arrangement, there must be $100 per year of development work on each claim and an affidavit must be filed attesting to the completion of this work. In addition to the land rental of $15 per claim per year charged under the mineral lease, a royalty is charged on the gross value of mineral production. For most minerals the royalty rate amounts to five percent. The base upon which it is calculated is the gross value of the minerals produced, minus the cost of their transportation from the property to market.[11]

The *California* state land system also provides for lode claims of 1,500 by 600 feet maximum extent with extralateral rights added for rectangular claims. Claims of any shape enclosing a smaller area are permitted, however. Placer claims of 20 acres each for individuals and 160 acres for associations are also permitted in the system. Placer claims may be no less than 10 acres in size, however, nor more than 160 acres. On certain lands, patents for mineral claims may be obtained, but on all lands the claims may be staked only after a state prospecting permit has been secured. This prospecting permit involves payment of a fee of $1 per acre for the first two years of the permit and may be extended for one year.

Upon discovery of a mineral deposit and the staking of the necessary claims on state lands, a mineral lease of 20 years' duration with a preferred right of renewal for successive 10 year periods can be obtained. Each lease commands a rental fixed at $1 per acre per year. Royalties are variable, however, but are specified in advance of discovery in the prospecting permit. The lease may be terminated upon 30 days' notice. Annual development work must be performed for claims held under state mineral leases and must equal at least $100 per year per claim. An affidavit must be filed attesting that such work has been done.[12]

The state mineral land systems in *Colorado* is similar in many respects to those of California and Arizona. A lode claim of 1,500 by 600 feet is permitted on state lands, and placer claims no larger than 20 acres (individual) or 160 acres (in association) are also permitted with a 10-acre tract as the minimum size. As in most other Western States, once a mineral has been readied for utilization on state lands, the system changes from one of location to one of lease. In general, mineral leases on state lands in Colorado do not have any specific time limit, although there is a 50-year maximum lease term within the incorporated limits of any city. As in Arizona and California, any Colorado state mineral lease may be terminated upon 30 days' notice, development work of at least $100 per year per claim is required, and an affidavit attesting to the performance of that work is also necessary.[13]

The state mineral land system used in *Idaho* varies from the systems in use in Arizona, California, and Colorado. In Idaho, both lode and placer claims are permitted, but their maximum size is set at 640 acres. Prospecting permits are required, and they have a two-year period and require $100 worth of assessment work for each claim. All mineral rights on state lands are reserved to the state, and no minerals on state lands may be patented. Once a mineral has been discovered under a prospecting permit and a claim staked that does not exceed 640 acres in size, a state mineral lease may be obtained.

State mineral leases in Idaho stipulate a minimum rental of 25 cents per year. Precise royalties under mineral leases are determined by the State Land Board, but there is a minimum required royalty of 2.5 percent of the value of the mineral production. Most Idaho state land mineral leases run for 10 years with a preferred right to renewal. On lands designated as school lands, however, mineral leases run for five years. As in the other Western States, a lease may be terminated upon 30 days' notice. In a provision that is also similar to other state land systems, there is a development work requirement of $100 per year per 20-acre tract.[14]

The state land system in *Montana* uses a maximum 1,500 by 600 feet claim size for lode claims and a maximum 20 acres placer claim, with provisions for a 160-acre association placer claim. As in other Western States, a prospecting permit is issued upon application to the State Land Board. Once a mineral has been discovered, however, it must be produced under a lease arrangement with the state. The lease rental in Montana includes a $100 initial fee for issuance of the lease. In addition to that, a royalty of not less than five percent for metals and not less than two percent for nonmetals is calculated on the gross value of production. The duration of each state mineral lease is determined individually by the State Board of Land Commissioners. As in most other Western States, there is a development work requirement of $100 per year per claim, although no affidavit attesting to the performance of the work need be filed.[15]

Table 1

EXISTING POLICIES OF WESTERN STATES[a] FOR GRANTING URANIUM LEASES ON STATE-OWNED LANDS

System Feature	Arizona	California	Colorado
Preference Method	Prior claim by discovery	First-come, first-served (prospecting) Sealed bid or preference (mining)	First-come, first-served
Rental	$15.00 per claim (20 acres)	$1.00 per acre (prospecting) $2.50 per acre (mining)	50c per acre
Length of time	20 years with renewal	20 years with renewal (mining)	10 years renewable with production
Royalty	5% with allowances	10% - 50% (prospecting) 20% (mining)	12½%
Development Required	$100 per claim	—	None
Maximum Area per Lease	20 acres	160 acres (mining)	640 acres some exceptions
Maximum Number of Leases	None	None	None
Prospecting Lease or Permit	Yes	3 year permit (prospecting)	—
Acres Leased for Uranium	150	None	150,000

Table 1 (Continued)

System Feature	Idaho	Montana	New Mexico
Preference Method	First-come, first-served	First-come, first-served	First-come, first-served
Rental	25c per acre	50c per acre	3 years @ 5c 2 years @ 50c 5 years @ $3
Length of time	10 years with renewal	10 years with renewal - open end	5 years 5 years option
Royalty	2½% - 12½% Sliding scale	5%	5%
Development Required	None	None	None
Maximum Area per Lease	640 acres	640 acres	640 acres
Maximum Number of Leases	None	None	None
Prospecting Lease or Permit	20 acre claim 2 years, then lease	No	No
Acres Leased for Uranium	Unknown - not segregated from other minerals	48,000	2,500,000

Table 1 (Continued)

tate	Utah	Washington	Wyoming	Oregon
ference Method	First-come, first-served	First-come, first-served	First-come, first-served	First-come, first-served
ntal	50c per acre	1st, 2nd year 25c 3rd, 4th year 50c 5th year $2.50	25c per acre	1st, 2nd year 25c 3rd, 4th year 50c 5th year $3.00
gth f time	10 years renewable with production	20 years with renewal	10 years with renewal	10 years with renewal
yalty	3% - 12½% Sliding scale $1.00 minimum	3%	5%	5% graduated to 10%
elopment equired	None	$2.50 per acre or pay state $2.50	None	1st, 2nd - $1.00 3rd, 4th - $2.00 or payment
imum rea per ase	2,560 acres	640 acres	1,280 ares	County
imum umber of ases	None	None	None	None
pecting ase or rmit	No	2 years	No	Yes
s Leased r Uranium	241,686	60,000	1,552,388	—

Data Available for Nevada

ce of data: Oregon State Land Department

On state lands in *Nevada,* those desiring to find and utilize mineral resources must first secure an exploration permit. This is good for six months, is issued at no charge, and must be obtained from the *county* in which the work is to be done. Once a geologically attractive area or a mineral discovery has been delineated, lode claims of 1,500 feet by 600 feet or placer claims of 20 acres per individual (with a maximum of 160 acres for an association) may be staked. In Nevada, there is also a 10-acre minimum on placer claims. Once a claim has been staked, minerals may be extracted under a lease arrangement with the State. The land rental for mineral leases in Nevada is $1 per acre per year, but royalties are variable. The actual duration of any specific mineral lease is also variable, but may not be longer than 99 years. As in the other Western States, there is a development requirement of $100 worth of work per year per claim. In Nevada, an affidavit attesting to the performance of this work must be filed. Mineral patents are allowed on some state lands in Nevada, but there is a five percent perpetual royalty attached to them.[16]

Those seeking mineral resources on state lands in *Oregon* must first obtain a prospecting permit as determined by the state department of geology and mining. On those state lands for which a prospecting permit has been obtained, lode claims of the standard 1,500 feet by 600 feet or 20 acre per individual placer claims (with a maximum of 160 acres for four association claims) may be staked. Mineral extraction from state lands is performed under a leasing system. The rental on state mineral leases is 25 cents per acre for the first two years, 50 cents per acre for the next two years, and $3 per acre every year thereafter. The leases are set for a primary term of 10 years and are renewable for each 10 years thereafter up to a maximum of 50 years. In addition to the annual rental paid on state lands acquired for mineral purposes, there is also a royalty charged. Each royalty is based on the gross price of the mineral commodity produced less transportation costs from mine to market. Up to a total annual output value of $1,000,000, the royalty is five percent. Up to an annual output of $1,500,000, the royalty rate increases to six percent, and from $2,000,000 up, the royalty rate is seven percent. State land leases in Oregon may be terminated upon 30 days' notice, and there is also a development requirement of $100 per year per claim.[17]

The concept of the mineral claim is not even used with respect to state lands in *New Mexico.* Nevertheless, under the New Mexico system, there are size limitations on individual mineral leases. The New Mexico law requires that no mineral lease shall contain more than 640 acres. The state's mineral leases run for a primary term of three years and a secondary term of two years. Any additional terms are five years each, and a preferred right of renewal is given to the current lease holder. Initial leases are awarded on a competitive basis. Under every state mineral lease there is a minimum land rental. This consists of five cents per acre per year during the primary term of the lease. During the secondary term, that is for the third, fourth, and fifth years of the lease, the annual land rental rises to 50 cents per acre. Beyond the fifth year of the lease, the yearly land rental climbs to $3 per acre. In addition to the land rental, royalties of two percent of gross mining returns plus two percent of any bonuses or premiums are charged. If the material mined happens to be uranium or precious stones, however, then the royalty is five percent of gross returns plus five percent of any bonuses or premiums. As in other Western States, there is in New Mexico a $100 development work requirement per year per lease.[18]

In *Utah,* all coal and other mineral deposits on lands that belong to the State are reserved to the State and cannot be patented. Use of state mineral lands by private individuals is carried out under a leasing system. For minerals exploration on state lands in Utah, a prospecting lease can be obtained that can cover no more than 160 acres in any one township. This is an unusually small area for a prospecting permit. Each prospecting lease used in Utah requires $250 worth of assessment work every six months and has a 10-year maximum duration. Once minerals are discovered on state land in Utah, 1,500 feet by 600 feet mineral claims may be staked and minerals produced under a minerals lease which may not exceed 2,560 acres in extent. Under the Utah state land leasing system, mineral land rental is set at not less than 50 cents per acre per year. Royalties are determined by the state land board. Each mineral lease runs for 20 years and is subject to renewal, but may be terminated upon 30 days' notice. Leases initially are awarded on a noncompetitive basis.[19]

Mineral exploration on state lands in *Washington* requires a prospecting permit. The fee for this prospecting permit is $5 for every 40 acres plus $5 for the permit itself, and the area covered must not exceed 80 acres, making it even smaller than the Utah prospecting lease. The state prospecting permit in Washington runs for two years, during which not more than five tons of ore may be removed for testing. The state mineral land system provides that coal leases may be obtained for not more than 640 acres. The maximum for other minerals, however, is 80 acres.

Under the State of Washington mineral leasing system, a land rental is charged for each mineral lease at 50 cents per acre per year. This remains constant for every year of the lease. In addition to the land rental, there is a royalty of five percent calculated on the sale price of the minerals. Nonfuel mineral leases in Washington normally run for five years with renewal rights for a maximum of 20 years. This term applies to nonfuel minerals. No state lands in Washington may be patented and any mineral lease may be terminated upon 30 days' notice. As in all of the other Western States but Utah, the State of Washington requires $100 worth of development work per year per 20 acres with an affidavit that such work has been done.[20]

In the state of *Wyoming,* mineral claims on state land are set at 1,500 feet by 600 feet and cannot be more or less. Lease rentals and royalties, however, are not established by statute but are fixed by the state land board. As in other Western States, a $100 per year per claim development requirement also exists in Wyoming, and the State also requires an affidavit attesting that such work has been done. Although there is a preferred right of renewal after the normal 10-year duration of mineral leases in Wyoming, this does not mean that the lease must necessarily be renewed on identical terms and conditions with the previous lease. Throughout the entire mineral leasing system for state lands in Wyoming, considerable latitude is left to the state land commission.[21]

B. PRIVATE MINERAL LAND SYSTEMS

1. General System Features

The variety of private mineral land systems in operation in the United States today is as great as the number of individuals and corporations engaged in mineral industry activity on private lands. At least in the nonfuel mineral sector, it may be safely said that no two private mineral land agreements are exactly alike. Under oil, gas, and coal utilization systems, many private land use arrangements have similarities. In fact, many oil and gas arrangements are almost identical. This is not true in the nonfuel mineral industries, however.

Most private mineral land systems distinguish between exploration and development and production. Prospective users of privately owned mineral rights often enter into *option agreements* under which they receive permission from the private land owner to do extensive exploration work before committing themselves to a formal lease or purchase of mineral rights. Thus, the exploration agreement has become a prevalent part of many private mineral land systems in operation in the United States today. The private exploration agreement generally involves land that is not otherwise open for mineral exploration, i.e., is not state or federal public land. In many cases, however, such arrangements also involve unpatented mining claims on public domain. In these instances, the owner of the unpatented claim treats the mineral rights thereon as his private property. As a result, private and public land systems have become thoroughly intermingled in many areas.

An arrangement used for actual mining purposes and occasionally for exploration is the *joint operating agreement*. This is a contract under which a mining firm or individual is, in effect, employed by the mineral land owner to enter and work the land for its mineral resources. The joint operating agreement may also be used for arrangements between co-owners of private mineral lands wherein they both agree to develop mineral deposits on a cooperative basis. A third variation of the joint operating agreement may involve an arrangement between separate mineral interest owners seeking a cooperative management of their separte, but often contiguous resources.

A private owner of lands on which the presence of valuable minerals is suspected may wish to retain his mineral rights while at the same time seeking to determine the feasibility of mining operations on that land. In arranging for mineral exploration upon his land, several basic types of arrangements and numerous variations of them are commonly used. The first includes the *exploration option agreement*. The second is the *purchase option agreement*, and the third is a *lease contract*. Under the first (the *exploration option agreement*), the minerals seeker conducts exploration at his own expense, and if satisfied with the prospects for profit, can then exercise an option to lease the land for mineral production purposes.

A purchase option agreement differs from an exploration option agreement in that upon completion of exploration work, the potential mineral producer's option may be to purchase the entire mineral interest or an agreed percentage of the land owner's mineral rights. Thereafter, the parties to the arrangement develop the property jointly as co-owners. Such agreements permit the minerals seeker to complete a specified amount of exploratory work before exercising (or not exercising) his option.

Under the third basic arrangement (a *lease contract*), the decision of how much and when to explore ordinarily is left to the minerals seeker. Failure to commence development or production operations or to pay rentals during the primary term of the lease, however, may be grounds for the termination of that lease. A fourth arrangement, a *straight exploration contract*, is often used simply as a contract for services to be rendered to the land owner and gives the conductor of the exploration work no interest in the minerals discovered. This is a common arrangement used by major as well as smaller mineral producing firms in subcontracting exploration work, rather than having it done by their own employees.[22]

All of these variations of exploration arrangements usually involve obligations on the part of the exploration entity that are stated as objectives or standards. There are many different types of standards used. Under some private mineral exploration arrangements, standards consist of drilling a specified number of holes to a given depth. In others, the objectives require taking a specified number of samples, removing a stated amount of overburden or ore, driving a tunnel or sinking a shaft to predetermined dimensions, completing a certain number of man-hours of labor, or blocking out a specified volume of rock in place.

Payment provisions under private exploration agreements may call for payment of cash or payment in kind. Generally, payments in kind are limited to mining agreements. Nevertheless, under some agreements, payments are made in corporate stock or other interest in the mineral rights. Payments are frequently made in installment but occasionally are made in a lump sum. Installment payments are often made on the simple basis of time, but they are also made on the basis of completion of specified amounts or stages of work.

Mineral *development contracts,* as they are currently used, are much the same as exploration contracts, and in effect are an employment contract between the owner of mineral resources and an operator involved in actual mine development operations. In many cases, these involve a simple fee paid for services rendered. In other cases, they involve an agreement whereby the mine developer receives an interest in the mineral rights. In the late 1800's, the latter arrangement, under which a firm that developed a property received some share in the return from the operations, was fairly common. In recent years, however, the utilization of subcontractors by major mineral firms has somewhat reversed the situation. Most existing development contracts normally involve provisions regarding the speed of mining, use of surface lands, locations of excavations, supervision of the work, and the manner and time of payment for the work. *Mining contracts* are similar, but simply go beyond development excavation to actual production. Such agreements also include provisions concerning the delivery or sale of the mineral material actually excavated and payment for waste excavation.

The *operating agreement* between or among co-owners of a mineral deposit usually designates one person (or firm), either one of the owners, or an outside party as the mine operator who is to be responsible for the development and mining of the minerals in the deposit. Mining operating agreements have become much more common in recent years, particularly in relation to large deposits where one or more of the owners of mineral rights has not been traditionally associated with the particular type of mining involved and finds it necessary to rely on the capabilities of another owner.[23]

All exploration and development arrangements in the nonfuel mineral industries, particularly the development provisions of mining options, are normally tailored to the physical characteristics (including location) of the particular mineral deposit, the economic status of the parties involved, and their motives for entering into the transaction. In general, such arrangements have several objectives. The first (on the part of the landowner) is to induce exploration and to secure mineral resource data for the benefit of the person who owns the particular deposit. The second objective (on the part of the minerals seeker) is to enable the potential producer to determine the character and extent of the subsurface mineral deposit prior to exercising (or dropping) an option to purchase or lease. A third objective that is commonly found in such agreements is the creation of immediate rental and royalty income for the landowner from mineral development. A fourth involves using the purchase option to encourage the potential mine operator to make substantial capital investments in the land in question. These objectives, of course, are not always compatible, and in some cases may be in direct opposition. For example, an agreement under which maximum early revenue is desired to induce investment may, in effect (and has in some cases), result in a reduction in the amount of information obtained about a deposit prior to exercising an option to lease or buy. Nevertheless, the primary objectives of both the mineral landowner and the mineral seeker or potential producer govern the relative emphasis given to the different provisions of each exploration and development contract. Motivation thus is an essential element of every private mineral land system.

There are also a variable number of systems in use on private mineral lands in the United States concerning actual mineral production. Under private mineral land systems, production royalty and land rental payments are common. In most cases, these serve to assure the owner of the mineral land a return in exchange for the utilization of his resources by others without incurring the attendant risk involved in sharing the profits of others or in his own entrepreneurial endeavors. A production royalty is actually a share of production revenue without regard (in most instances) to cost incurred in achieving that production. Under some royalty agreements, however, specified costs may be deducted from revenues before royalties are calculated.

The practice of leasing privately held mineral land for exploration, development, and production by a third party has become perhaps the most commonly used method of producing *hard minerals* from private lands in the United States. *Hard minerals* include coal, and in the coal producing regions of the Eastern United States, land leasing is the most common type of private mineral land system. It is also common in the Western United States for nonfuel minerals. It is common, in fact, even on public domain where unpatented mining claims are involved, and the owner of an unpatented claim is considered to have ownership rights to the mineral resources on that land, regardless of the opinion of his status held by the federal government.

The simplest form of royalty system involves periodic payments to the owner of the land as a mineral commodity is produced and sold. Although based upon this simple concept, an innumerable variety of arrangements have developed. Some of these include *overriding royalties, independent royalties,* and *production payments.* All of these have various legal and tax implications, and have also had varying effects upon the economic and technical conditions under which nonfuel mineral resources have been utilized. Private mining leases commonly require payment of minimum royalties which are, in effect, land rent, and must be paid whether production is or is not made from the land in question. Arrangements are occasionally made for royalties to be charged against any operator income that is even remotely related to the utilization of the mineral resources contained in the land. As one authority has noted, "The possibilities are limited only by the imagination of the parties."[24]

A common royalty arrangement in the use of private mineral land arises when the owner of all of the mineral rights for a given area of land leases that land but reserves for himself a share in the monetary value of any production of minerals from the land either as partial or complete consideration for the granting of the lease. Such royalty reservations take a variety of forms. Occasionally, the landowner reserves a royalty based upon a fixed sum of money for each ton of material removed and sold (a common arrangement on coal lands), or his reservation may consist of a flat percentage (or fraction) of the value of the ore removed or of the mill or smelter returns. Other arrangements involve a graduated percentage of the value of the ore removed (or smelter returns) according to the quantity produced. In other cases, the royalty is set at a fixed percentage of the market value per ton of ore. Thus, uranium leases on private land often provide for variable percentage royalties depending upon the uranium oxide content of the ore. Other royalty reservations involve combinations of these features.

In addition to payments that are based on actual production, private mineral land leases also commonly provide for a minimum royalty to be paid regardless of whether or not there is any mineral production. Under certain circumstances, there are also haulage royalty provisions or charges for the privilege of transporting ore from workings on adjacent land to or across the surface of the leased premises, and sometimes a delay rental is charged for the privilege of postponing mining activities. The haulage royalty is a common charge where mining is done on Indian reservations, which, for all practical purposes, may be considered private land as far as the nonfuel mineral industries are concerned. Haulage royalties (or right-of-way rents) are also generally provided where a leasing operator is working contiguous mining areas that have been leased from more than one landowner. The amounts of such royalties charged and the methods under which they are computed are, of course, fixed by the terms of the individual mineral land lease.[25]

The bases for computing royalties under a mineral land lease on private lands are often dictated by several factors. The type of minerals being mined usually exerts a strong influence, because this in turn effects the cost involved in beneficiating or otherwise treating the commodity before marketing. A second major factor is the proximity of the mine to ore treating or marketing facilities. The amount of profit that the mine operator contemplates is also a factor, as are many other economic and technical factors involved in the utilization of the specific mineral deposit in question. *Throughout the nonfuel minerals industry, there is no standardized royalty rate.* There may be regionally accepted royalties, and there may be widely accepted royalty rates for particular commodities, but these may vary from one region to another and from one type of deposit to another. Royalties on most solid nonfuel minerals, however, are normally calculated as a given percentage of the value of the ore removed, or on a sliding scale according to the quantity produced, with a lower unit royalty charged against a higher rate of production. The net figure upon which royalties are calculated varies between smelter returns, gross sales, and gross value of output less specific expenses. Another variation from one arrangement to another concerns whether royalties are to be paid when material is mined, when it is shipped, or when it is sold. Although a few hard mineral leases are established with royalties based on a specific price per ton of mineral mined or sold, usually some percentage basis is perferred in order to remove the uncertainties caused by the frequent price changes that occur in the nonfuel minerals industry.

Minimum royalties are payments made by the mineral producer to the landowner whether or not the mine is worked and whether or not there is any significant production. Provisions for minimum royalties are typically used in nonfuel mineral lease operations. These minimum royalties are sometimes set at a fixed annual sum, at a fixed annual sum per acre, or are variable. The basic purpose of the minimum royalty is to insure diligence and speed in mining and development activity on the part of the lease holder and to avoid the possibility of mineral producers tying up large areas of ground at little or no expense to themselves, simply to eliminate potential competition. The minimum royalty is, in effect, a land rent. Minimum royalty charges generally cover annual periods, although this is by no means uniform throughout the entire nonfuel minerals industry.

A third type of royalty, which has been called the *independent royalty,* involves an interest in gross production from a mine only and is distinguished legally from the interest in the in-place mineral rights themselves. The distinction is essentially a legal one, rather than an economic or engineering variation.

An *overriding royalty* involves interest in the production of minerals from leased land and is usually created by the working interest of a third party in a lease. Under such an arrangement, the lease holder's interest in a mineral deposit is distinguished from the actual landowner's. Where an overriding royalty is involved in a mineral lease, it is analogous to the amount of rent held out by a leasing tenant when he sublets his premises to another. The overriding royalty interest is normally created by reservation when a mineral lease holder transfers his operating rights by assignment or sublease, retaining his own or overriding interest. The overriding royalty frequently comes into being as the result of an attempt to gain speedier or increased production from a particular mineral deposit. The original lease holder, who is obligated to pay a production royalty to the owner of the mineral lands, subleases all or a portion of the deposit and retains a royalty over and above the amount going to the land owner. If a venture is of a particularly speculative nature and if the lease holder does not have sufficient funds for mine development himself, he may assign the lease to a third party who does have sufficient capital and perhaps technical capability to explore and develop the mine, retaining for himself a percentage of production which overrides the land owner's royalty payments. The range of possible transactions and specific provisions is enormous.[26]

In the production of nonfuel industrial minerals in the Western United States, the overriding royalty has become a very common provision in mineral land systems, particularly where speculators have been able to obtain rights or mineral leases from the federal government and then have subleased these rights to bona fide mineral producers. In many respects, any royalty charged by the holder of an unpatented mining claim could also be considered (in economic terms at least) an overriding royalty with the override going to the claim holder and a zero royalty going to the actual owner of the land, the federal government.[27]

Ore payments normally arise in the nonfuel minerals industry in situations very much like those which create the overriding royalty. Ore payments differ, however, from the overriding royalty in their duration. An override normally continues throughout the life of the lease. The ore payments, however, terminate upon payment of the specified sum called for in the agreement. In effect, the ore payment arrangement is a purchase of minerals from a mineral lease holder.

In all of the various private lease, purchase, and option arrangements in use today, there are also tax considerations. These have become extremely important in all of the arrangements made under private mineral land systems in the United States. At the present time, in fact, tax considerations are probably the single most important factor in the development of the specific features of private mineral land systems. They are now far more important than the geologic and other technical characteristics of the mineral deposit involved, and even more important than the normal economic conditions of the market situation in which the particular mineral is produced and sold.

Most nonfuel mineral leases today provide for a specific interval under which the lease is effective, rather than an indefinite period based on continuing output. The specific durations of individual leases are, of course, quite variable and depend mostly upon the nature of the mineral deposit involved, the economic and geologic situation, and the motives of the contracting parties. Probably the most important factor in the variation of lease duration is the size of the mineral deposit involved and the intended rate of production. In addition to the total elapsed time of the lease, many private land mineral systems also include schedules for the performance of production and development work, as well as schedules of the payment of rentals, royalties, or other sums.

In recent years, it has become common for environmental control provisions to be inserted in private mineral land leases. In the earliest days of mineral activity, such provisions were also used, but their concept and motivation was slightly different. In many private mineral land arrangements in the last century, a primary concern of the landowner was that the tailings or other solid waste disposed of by the actual mine operator would remain the property of the land owner and that the mine operator would retain no ownership interests in the waste products of his operations. Thus, even in the 1800's, solid waste resulting from mine operations were considered to be of potential future value. Modern views of the solid wastes created by mining have shifted somewhat from this earlier view.

Many private exploration and mining agreements now include provisions for arbitration by an impartial third party in the event of disputes which arrive in the conduct of the agreement. In many instances, such arbitration is used in place of litigation in the courts. In other instances, it is simply a prior or preferred procedure.

Another variation of the private mineral land system, in addition to outright purchase and the many variations of lease arrangements, is what has been termed a *sale of minerals in-place*. This arrangement is established if an agreement authorizes a producer to remove minerals from a given deposit and provides for a lump sum or other payment related directly to that removal.

Occasionally, leases of private mining land may contain provisions requiring the payment of advanced royalties or bonus payments at the time of the execution of the lease. Often this advance amount may be credited against future royalties that become payable when production commences. Where there is no provision for such credit, the lump sum payment is usually termed a bonus payment and in effect constitutes the initial inducement to the landower to award a mineral lease. The amount of the bonus payment, of course, varies widely and depends upon the anticipated value of the lease to the mine operator and the real or potential competition for the use of the land in question.

2. Examples of Current Private Land Systems

Many mineral prospects acquired by both large and small mining companies are obtained even today directly from an individual prospector, his family, or a middleman acting as a promoter. Few attractive mineral prospects today are found on ground that has not been subject to mineral location or lease at one time or another in the past.

The outright purchase of a mineral property has become a rarity. In fact, it is now found only where the potentialities of the property have already been well examined and developed. The classic example of the straight purchase of a mineral property still remains the cash sale of 60 percent of the Chuquicamata (Chile) Mine to the Anaconda Copper Mining Company for $73 million *in 1923*. At the time, however, 300 million tons of copper ore averaging 2.23 percent copper had been blocked out.

Where ore reserves have been thoroughly blocked out or are strongly indicated, the sale value of a mineral property can be calculated fairly accurately by conventional means, employing the concept of the present value of future expected earnings. Very few mineral properties are in such a state at time of purchase, however. If they are, the present owner usually retains and operates them himself. If they are not, nobody is likely to want to buy them.

Dependent upon local conditions, purchases of mineral properties may be effected at a better price than that arrived at by present value calculations, or extra concessions may have to be granted by the buyer in order to take into account undeveloped orebodies. Such concessions generally involve the use of some form of participation in future profits by the current owner.

Under most private land systems in existence in the United States today, an *option to purchase* is one of the most common arrangements. Under this arrangement, for certain concenssions (usually the performance of a certain amount of exploration and development work, and/or relatively small interim payments), the owner of the land agrees to sell the property to the interested producer at a future date at a predetermined price. The determination of this price in many cases becomes an important feature of this mineral land arrangement. Nevertheless, the terms of the option in many other instances make the final price of relatively little consequence.

Another arrangement that is common is the *lease-purchase agreement*. Under such an arrangement, the seller of the mineral property receives a royalty once the property is brought into production. This royalty is based on the value of the ore produced. Such royalty payments accrue as a credit towards final purchase at an agreed-upon price, if the minerals producer wants to acquire ownership of the property. In some instances, the royalty is paid as a straight percentage royalty, but this does not work to the advantage of the minerals producer, nor does it really work to the advantage of the property owner. Such an arrangement tends to encourage the high-grading of the mineral deposit, the removal of only the highest value material, and the leaving behind of considerable values of mineable ore. A more equitable and economically sensible arrangement involves a sliding scale royalty designed so that the minerals producer is not only economically able to but is encouraged to mine lower-grade ores. In the uranium mining districts on the Colorado Plateau in the 1950's, a common sliding royalty scale was two percent where uranium oxide concentrations were between 10 and 15 percent and the total marketable value of the mined ore was about $16 a ton. This royalty increased to from three to four percent where uranium oxide concentrations were 20 to 30 percent and the ore valued between $25 and $30 a ton.

Reputable minerals-producing companies usually demand long-term leases of from 10 to 30 years where it is necessary to operate under a leasing arrangement with a private owner of the land. It was only in the days of the high-grade bonanza deposits that short-term leases were in demand. Under most lease-purchase arrangements, almost any final price for the land can be promised. If the price is too high, the arrangement becomes a straight lease and no sale is ever completed. If the price is within reason, however, the minerals producer gradually acquires ownership through the accrual of royalty payments.

Participation is a commonly used alternative to outright purchase of mineral property. Under this arrangement, various kinds of agreements can and have been made between mineral producers and mineral land owners. For example, the minerals producer may agree to bring a mine into operation, with the mineral deposit owner taking his compensation in the form of a royalty on production, a percentage of profit, or as a percentage of stock in a new company to be formed specifically to operate the mine. In another alternative, participation may be in the form of a stock option, where the minerals producer agrees to invest a certain sum in exploration or development with the right to purchase a certain percentage of stock at a predetermined price at the end of a fixed period or in several stages.

Another arrangement, the *royalty participation agreement,* is sometimes utilized as a compromise between leasing and full participation in profits (or losses). Under such an arrangement, it may be provided that the owner shall receive a royalty until the minerals producer has recouped his initial investment; then the royalty ceases and profits are divided on a predetermined basis. A typical example of this type of arrangement was made between the Volcan Silver Lead Corporation and the American Smelting and Refining Company (Asarco) for the Galena Mine in the Couer d'Alene district of Idaho in 1947. At that time, American Smelting and Refining took a 30-year lease with a 30-year extension privilege. Asarco guaranteed that it would make exploration expenditures in excess of $1,000,000, and also agreed to pay $500 per month as advance royalties recoverable from future earnings. Asarco further agreed that when production began it would pay 10 percent of net smelter returns to the landowner, the Volcan Silver Lead Corporation. After Asarco had recovered its invested capital and accumulated $500,000 of working capital, royalties would then cease and all profits would be split down the middle. By 1952, Asarco had spent $2.5 million, had developed a large orebody, and was producing ore from the property at the rate of 1,000 tons per day.

A fairly common type of private mineral land negotiation involves the *option cash payment* arrangement where in the fixed price on the mineral property is considered to be reasonable in view of potential ore reserves. This arrangement is used with the type of deposit that puts a great responsibility on the examining geologist in appraising the geologic potential of the mine. He must usually size up a deposit on very short acquaintance and put a dollar value on its untested potentialities.

The schedule for an option-cash payment arrangement follows a fairly standard pattern. First, there is a free period of from 30 days to six months in length, during which a preliminary examination is made by geological, geophysical, and geochemical means and perhaps including the drilling of one or two exploratory drillholes. Commonly, there is a preliminary cash payment required that reimburses the owner for claim location and assessment work during this period. This also serves as a hedge against the possibility that the entire project may be rejected, and at the same time reduces the chance of optioning to another prospective investor. The pattern of payments after the initial "free" period involves first a lump sum payment, with monthly payments during development, followed by a second and greater lump sum payment. This is followed in turn by increased monthly payments during continued development, with a final payment made at approximately the same time as full-scale production is begun.

A typical example of an option-cash payment agreement for a relatively small nonfuel mineral property, optioned at a total purchase price of $250,000, would follow approximately the following pattern. The first six months would be free. At the end of six months, there would be another six-months' period of payments of $500 a month, resulting in a total payment of $3,000. This would be followed by a cash payment of $20,000. Thereafter would follow a year of monthly payments at $1,000 a month, to be followed again by a cash payment, this time of $40,000. This would be followed by another year with cash payments of $2,000 a month. At the end of this time, three years from the initiation of work, the property owner would have accumulated $99,000 in combined monthly and lump sum cash payments. At the end of the three-year period, a final payment of $151,000 would be made, bringing the total purchase price to the previously agreed upon $250,000. Of course, if detailed exploration, evaluation, and development had shown no useable mineral deposit at the end of three years, the final payment would never have been made. The same is true for each of the specific intervals within the three-year development period. Payments during an option period usually do not exceed one-third of the total purchase price, and any money paid during the option period is retained by the owner of the land even if the option is dropped.

A simpler type of option agreement can be illustrated by another example wherein a relatively small mining property was acquired for $50,000. This was paid off at the rate of $1,000 per month for 50 months. Such an option is usually signed after only a preliminary examination by an exploration geologist, and the total purchase price must be fixed before any detailed testing has been done. There exists, under such a situation, a severe problem for the potential minerals producer in determining an equitable price for the option and for the property. Fixing such a price depends not only upon geological and engineering factors, but upon economic ones as well. Variations in the commodity market that may be expected and the policies of the investing company must also be considered. Wherever possible, the value of a mineral property is based roughly upon present value calculations, if possible future earnings can be reasonably estimated. Nevertheless, only from one-third to one-half of the purchase price of mineral properties is usually dependent upon present value calculations. The remainder depends upon the stage or development of the mine and what, in many respects, amounts to the going price for similar mineral properties in the same area.

The minimum size of operation in which the potential minerals producer is interested frequently determines the price offered for a particular property. If a producing company's policy demands an operation of a certain size, and if upon examination a deposit can be determined to have a sufficient mineral potential, then a rough approximation can be made (using minimum figures for rate of mining, life of mine, tons of ore reserve required for operation, profit expected per ton, anticipated delay before full operation, the investment required for plant facilities, the present value of future earnings) of an evaluation figure based on about one-third of the present value of expected future earnings. For example, a property that could be expected to support a rate of mining of 25 tons of ore per day over a five-year period would have to have 40,000 tons in its orebody. If profit could be expected at about $15 per ton and if a one-year delay were expected in the period between acquisition and full production, then the investment required would be $250,000. Using a six percent interest rate,the present value of future earnings would be about $280,000. The purchase price for such a property would be one-third of that or about $93,000. Similarly, for a 1,000 tons per day operation over a 10-year period, a total orebody size of three million tons would be required. If, for such a deposit, an approximate future profit of about $3 per ton were expected, a development period of four years, and an investment of $5 million required, then the present value of future earnings (again capitalized at six percent) would be about $2.3 million. One-third of ths would be about $775,000. For a much larger operation, say with a 5,000 tons per day capacity and a 15-year useful life, a deposit of 25 million tons would be required. At an approximate future profit of about $2 per ton, a five-year delay between acquisition and the initiation of full scale production, and an investment requirement of $26 million, then the present value of future earnings, again capitalized at six percent, would be $14.5 million. One-third of this would make the purchase price for this property $4.8 million. These, of course, involve only rough rules of thumb, and numerous other conditions are taken into account in estimating rough purchase prices for mineral properties.

Going prices in a given area can be determined by an examination of other mines or mineral lands that have been sold in an area within a recent period. For example, in one area, not too many years ago, in a district of relatively high-grade ores, most mineral properties in the area sold for a value equal to about 0.2 to 0.3 percent of the gross metal value potential of the deposit. This apparently was based on similar appraisals and similar geologic opinions regarding metal content. The 0.2 to 0.3 percent factor, however, did not represent an accurate appraisal, only a rule of thumb. Under this arrangement, a three million ton orebody containing three percent copper valued at a market value of 30 cents per pound would give a total metallic content in the orebody of $54 million, and 0.2 percent of this would give an estimated purchase price of $108,000. Of course, if a particular property does not yield sufficient ore after testing to justify the purchase price that has been set or the size of operations required, then the option to purchase is normally dropped.

C. EFFECTS OF NON-PUBLIC LAND SYSTEMS

There is little doubt that the terms and conditions of mineral tenure on non-public lands in the United States vary, and vary widely. Numerous factors and conditions are associated with the variations among both state mineral land systems and private land systems. As the systems differ, so also have the effects of the systems on the utilization of mineral resources differed.

The present terms and conditions on non-public mineral resource tenure depend in part upon the nature of the original title to the land. Provisions of both state and private land systems in those states that were (and still are) largely public domain are not the same as those in the areas east of the Mississippi River, although there are some similarities. Nevertheless, the presence of public domain land and its previous existence have apparently had an effect on non-public mineral land systems.

Under state land systems currently in operation in the United States, there is very little difference in the method of title transfer regarding mineral resources. There really is no title transfer, with ownership of all state-owned mineral resources being retained by the various states and utilized under leasing systems. On the other hand, under private land systems, there is considerable variation in the methods of title transfer used. These range all the way from outright sale of land and mineral resources, through numerous leasing and option arrangements, to the sale of minerals in-place.

The method of title transfer in and of itself does not seem to have been either a serous deterrent or incentive to mineral resource utilization on state lands. Rather, the other provisions of state leasing systems seem to have been far more influential, in some cases encouraging, and in other cases discouraging efficient mineral resource utilization. In private land agreements, the method of title transfer appears to have been much more important than under state land systems (probably because more alternatives are available), but it is still overshadowed by other system features in its effects on mineral resource utilization.

The land areas involved in non-public mineral land systems have varied enormously. Although less variation is found in state land systems as compared to private arrangements, even from state to state and sometimes within a single state, the variation has been great. Most state land systems use some multiple of 20 acres in defining the land areas involved in their mineral leasing systems. A few set minimum areas of consideration at 10 acres. Maximum areas involved in any one arrangement range from 20 acres up to more than 5,000 acres. In some instances, where there are no restrictions on multiple claims, the maximum is set simply by the amount of state land available.

Under private land systems, the same factor tends to set a maximum while there is almost no minimum. Areas of less than an acre have been involved in some private agreements, while the maximum acreages included under any single arrangement have been quite extensive, and in fact limited only by the availability of private land and the attitudes of private land owners. In many Eastern States, however, this latter factor has often placed severe restrictions on the amount of land economically available. In many instances, the inability of a minerals seeker to obtain rights to a sufficient extent of land in private ownership areas has made mineral resource development impossible. Particularly in areas where private land ownership is divided among many small-area owners, adverse attitudes towards mining activity, combined with delusions regarding the potential value of mineral deposits, have seriously hampered both minerals exploration and development. In fact, there is little doubt that this is one of the primary reasons for the relative lack of metallic mineral development in the states east of the Mississippi Valley.

The length of mineral tenure also varies widely under existing systems of mineral utilization on the non-public lands of the United States. Under private agreements, mineral tenure may range from less than three months under some short-term exploration options to as long as 20 years or more under long-term production leases. Of course, under absolute ownership systems, the length of tenure is theoretically infinite, and many mineral rights on private land are owned outright by the minerals producer.

The effects of such variations in mineral tenure are difficult to assess, because they cannot be considered in isolation from the other terms and provisions of private mineral agreements. It is most likely, however, that demands by landowners for excessively short tenure periods have discouraged efficient mineral resource utilization. At the same time, it is also probable that excessively lengthy tenure periods have slowed mineral deposit development when not accompanied by adequate work requirements. Under state land systems, there have likewise been wide variations in mineral tenure, ranging from 30 days to a theoretical eternity. The effects of these variations have apparently been the same as those caused by such differences in private land systems.

Perhaps the greatest degree of variation in non-public mineral land systems has been in the means of payment involved. Under most state land systems, the means of payment have been established by statute and this has tended to decrease the range of state-to-state differences as well as differences within each state. Under private land systems, the variation in methods of payment has been enormous and virtually unmeasurable. In recent years, however, income tax considerations and the elaborate regulations of the Internal Revenue Service have tended to congeal certain payment methods, if not the amounts involved therein.

Payment methods have been one of the principal factors in determining the extent and scheduling of mineral resource utilization on the non-public lands of the United States. Competitive bidding, either openly or by sealed bids, has tended to discourage nonfuel mineral industry activity. High charges for exploration rights have had a smilar effect. On the other hand, payment arrangements that have allowed the acquisition of a maximum amount of mineral deposit information at a minimum cost and have required the landowner to share some of the uncertainties involved in mineral resource utilization have encouraged the more efficient use of mineral resources.

Performance requirements have become almost uniform throughout most existing state land systems in the United States. On private lands, however, they have remained quite variable. The requirements included in most state land systems are almost minimal, and their effect has probably been the same. In private land agreements, however, the performance requirements are normally designed to achieve a specific objective regarding the exploration or development of a particular mineral deposit. In most cases, they have been effective in achieving those objectives.

Under all state land systems in operation in the United States today, the state retains an interest in the lands that it allows to be used for mineral purposes. In some states, the interest that is retained is only a small percentage royalty in perpetuity. In other states, the interest retained is substantial. The effects of the retention of interest are difficult to assess in isolation. The same is true of such retention under private mineral land agreements where the amount of retained interest ranges from zero to almost 100 percent. Nevertheless, it is apparent that the greatest influence of the retention of interest is on post-production activities. Where the original landowner retains a substantial interest in the land, there is less incentive for the minerals producer to improve the land after mining operations are complete. Where the mineral producer has most of the interest in the land, however, there is a greater tendency to try to gain additional profit by converting it to a non-mineral use or by selling it to another potential minerals producer.

Provisions regarding the environmental effects of mineral industry activity are found in many state land systems, particularly in areas of substantial rainfall and moderate to dense vegetation. In arid regions, such provisions are comparatively rare, perhaps because of the realization that in such areas it is difficult for mining to adversely affect an already harsh environment. Most such provisions in state land systems have been concerned primarily with the biological and aesthetic environments. The effects of mineral industry activity on water and air resources are usually dealt with under separate, specific legislation that pertains to other activities as well as mining.

Provisions regarding mineral exploration, development, and production activities on non-public lands vary somewhat according to the specific commodity involved. Under the different state land systems, the variation is less than that found under private land systems.

Within any one state the variation is also usually less than that found in the federal mineral land systems. Under most state systems, all nonfuels are treated alike, although a number of states treat sulfur, uranium, and sand and gravel as distinct from other nonfuel mineral commodities. The distinction between sand and gravel and other nonfuel minerals is most common.

The effects of these commodity distinctions have themselves been mixed. In some states (e.g., Minnesota), mineral land systems have been designed specifically for a single mineral and then broadly applied to other minerals as well, often inappropriately and with an adverse effect upon mineral resource utilization. In other states (e.g., Oregon), the systems have been broadly defined to fit many minerals in a minimum of separate (but realistically defined) categories.

Under private land systems, commodity distinctions have been extensive. Variations have, in fact, been on an individual deposit basis. The effects, generally, have been to encourage efficient mineral resource utilization by allowing each agreement to be tailored to the physical and economic realities of each particular situation. Nevertheless, some types of system features are common to broad groups of mineral commodities and to general classes of mineral deposits.

Under most state land systems, the discretionary rights of either the state or the minerals producer to change the terms and conditions of any mineral land agreement during its life are severely limited. Most state systems do provide for changes at regular and predetermined renewal periods. The same is true under private mineral land arrangements. The effect of this restriction on unilateral contract changes has been to assure much greater stability in state and private land systems. This has encouraged the optimum utilization of nonfuel mineral resources on state and private lands.

FOOTNOTES

1/ *American Law of Mining,* Denver: Rocky Mountain Mineral Law Foundation, 1960.

2/ *Ibid.*

3/ U.S. Department of the Interior, *Special Report on State Mineral Disposal Systems.*

4/ *Ibid.*

5/ *Ibid.*

6/ *Ibid.*

7/ *Ibid.*

8/ *Ibid.*

9/ *Ibid.*

10/ *Ibid.*

11/ Victor Verity, *Laws and Regulations Governing Mineral Rights in Arizona,* Tucson: 1965.

12/ State of California, *Legal Guide for California Prospectors and Miners,* 1965.

13/ State of Colorado, *Colorado Revised Statutes,* 1963.

14/ State of Idaho, *Idaho Code,* 1967.

15/ W.L. Stout, *Montana Mining Law.*

16/ M.J. Gallagher, *Nevada Mining Claim Procedures,* 1962, and M.J. Gallagher, *Nevada State Mining Laws,* 1963.

17/ State of Oregon, *Oregon Revised Statutes.*

18/ G.B. Hayes, *General Mining Rules and Regulations,* Santa Fe: State of New Mexico, 1965.

19/ State of Utah, *Utah Code,* 1953.

20/ State of Washington, *Revised Code of Washington,* 1951; M.H. Van Nuys, *An Outline of Mining Laws in the State of Washington,* 1953; W.S. Moen, *Mineral Rights and Land Ownership in Washington,* 1962.

21/ Wyoming, *Wyoming Compiled Statutes,* 1957.

22/ David H. Vernon and Ben Shantz, "Exploration Contracts," *Mining Law,* Vol. 3, New York: Matthew Bender and Co., Inc., 1960, pp. 1-28.

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24/ Richard L. Helmick and John H. Tippit, "Royalty Interests and Ore Payments," *Mining Law,* Vol. 3, New York: Matthew Bender and Co., Inc., 1960, p. 438.

25/ *Ibid.*

26/ Helmick and Tippit, *op. cit.,* pp. 478-479.

27/ *Ibid.*

CHAPTER 16

THE EXISTING PUBLIC LAND SYSTEMS

Have the present systems of public land policy had measurable effects upon the utilization of nonfuel mineral resources on the public lands?

A. THE EXISTING SYSTEMS

1. The Various Systems

The nonfuel mineral industries in existence on the public lands of the United States today actually operate under one or more of three distinct mineral land systems. The first is a mining claim *location system* adopted in the late 1800's from local rules and practice developed in the various mining districts of the Western United States. The second is a minerals *leasing system* developed in the early 1900's essentially for the fuel minerals and for certain nonmetallic, nonfuel minerals with other than local markets, specifically phosphates, potash, sodium salts, and sulfur. The third system is a mineral *commodities disposal system* involving the discretionary sale or grant of specified industrial minerals. This last system was developed in the 1940's and 1950's.

2. The Minerals Location System[28]

The system under which mining claims may be located (marked and recorded), held, and worked on the public domain of the United States originated in the local mining districts of the Western United States during the California gold rush of 1848 and 1849. It had its roots in English Common Law, but combined elements of Spanish-Mexican and German mining customs as well. The system developed from the customs of the miners which were codified in the form of local rules or mining district regulations. These provided the foundation upon which the Congress enacted in the late 1860's and early 1870's the laws defining the minerals location system.

Under the location system as established by the Mining Act of 1872, the basic statute defining the system, mining claims of a given maximum size may be located upon the public domain by citizens or those who have declared their intentions to become citizens, or by a corporation created under the laws of the United States or any of its individual states. The types of claims defined under the Act are two. The first is a *lode claim,* and it is specifically applicable to lands containing veins or lodes of quartz or other rock in-place bearing gold, silver, cinnabar, lead, tin, copper, or "other valuable deposits." Claims on such lands for such minerals are called lode claims regardless of the actual geologic structure encountered. The second type is the *placer claim.* These claims were designed to be located on lands containing all forms of deposits excepting quartz or other rock in-place, essentially for use with placer deposits, as the name implies. They have been used since with other types of relatively flat-lying deposits as well.

The lode claim was originally designed to be no more than 1,500 feet in length (along the strike of the vein) and 600 feet in width (300 feet on either side of the vein) and in the form of a rectangle or a parallelogram. A rectangle of such dimensions covers an area of approximately 20 acres. The placer claim was designed not to exceed 20 acres for each individual locator, but a maximum of 160 acres was allowed under an *association claim* of as many as eight individual locators. The provisions of the law with respect to the size and dimensions of lode claims were designed specifically for gold-bearing quartz veins that were relatively narrow in width, longitudinal in general shape, and steeply dipping or vertical in attitude. The approximately 20-acre maximum limitation on the size of a claim (i.e., the 1,500 by 600 feet maximum extent) was designed essentially for small mines operated by individuals or small firms on a relatively small scale. Even in the earliest days, however, one claim was frequently not enough to cover a deposit.

Strictly speaking, the lode and placer claims were the only types of claims established under the Mining Act of 1872. There were, however, two other types of areas designed for mineral purposes. The first was the *mill site,* and the second was the *tunnel site,* both of which are sometimes also referred to as mining claims or locations. The law actually provided for two types of mill sites. One was a mill site to be used in conjunction with a lode claim. It was to consist of land that was not contiguous to the vein or lode being used by the mine claimant, but rather was to be non-adjacent surface ground to be used for ore milling purposes. Like the mining claim, it could be patented (purchased from the government). It was not to exceed five acres in extent. The second type of mill site was to be used for a quartz mill or reduction works that was not related to any particular mining claim. Generally it was considered that either type of mill site should be on "nonmineral" land.

The location of tunnel sites for the development of underground mines was governed by local rules prior to the enactment of the Mineral Location Law of 1872, and that act in effect simply recognized the customs of miners then in force. It gave the proprietor of a mining claim the right to drive a tunnel into his claim from a site not on the claim. It also gave him the right to possess 1,500 feet of any blind veins intersected by the tunnel and not previously known to exist that were intersected within 3,000 feet from the first working face of the tunnel, that is, from the point at which the tunnel actually entered beneath surface cover. Unlike a mill site, however, a tunnel site could not be patented.

Under the original location system, before issuance by the government of a patent for the land claimed, the locator who had in good faith made a *discovery* of mineral in-place and had marked the boundaries of his claim according to the position of the vein, as he believed it to exist, was protected (at least against other mineral claimants) in his possession of the surface within the claim boundaries. Initially, the law was designed so that a prospector finding a deposit of a valuable mineral in-place could immediately mark on the site a notice of his discovery and then proceed to designate (up to the maximum dimensions allowed under a lode claim) the extent of surface area that he intended to work. Upon completion of a required amount of *discovery work,* the exact amount of which was left to the various state laws, he could apply for patent for the claimed land from the federal government. Upon decision by the federal government that the claim was valid, the prospector or mine operator would receive title to the area claimed upon payment of a per acre patenting fee of $5.00. Thereafter the land would be his in fee simple to work or otherwise dispose of as he saw fit. Essentially the same was true of the placer claim and the mill site "claim."

Even in the earliest years surrounding the passage of the Mining Act of 1872, however, the discovery of a valuable mineral in-place in a given area was not a single event such as the finding of a buried chest of gold coins. It was thus necessary for some type of *prediscovery protection* to develop. This came about in the form of the *unpatented mining claim* and the *doctrine of pedis possessio.* This doctrine held that even before the legal discovery of a valuable mineral in-place, a prospector who was in actual possession of land that had been marked out as a mining claim and who was diligently searching for a valuable mineral had a right to remain undisturbed on that property, and was protected against any entry by another private party. This right was contingent upon the actual occupancy of the claim and persistent, diligent following of work designed to yield the discovery of a valuable mineral. Where the boundaries of a claim had been definitely marked, the prospector's rights were usually held to extend to the entire claim. The doctrine of *pedis possessio* did not, however, protect the prospector against the open and peaceable entry upon that land of another party for nonmineral purposes, nor was it applicable against the United States Government.

The federal law presented no explicit procedure for the location of either lode or placer mining claims and left this prerogative to the various states in which public lands were found. Those procedures now are largely prescribed by state statutes, which outline various manners of posting and recording location notices or certificates and the manner of marking the boundaries of a mining claim, performing the required discovery work (which also varies from state to state), and recording the location notice or a location certificate in the county in which the claim is situated. The order in which these steps is performed has been considered immaterial so long as they are all performed within the maximum time permitted by state law or before an intervening claim by another private party.

Subject to certain statutory exceptions, the owner of an *unpatented* mining claim has had the right to exclusive possession of that land which he has claimed, and he retains that right as long as he complies with the acts of Congress and the appropriate state laws. Where patenting has been approved, upon payment of the purchase price (patenting fee) and issuance of the final receipt by the appropriate federal officer, the applicant for a patented mining claim holds the claim in fee simple. His title is only assailable by an action brought by the United States for correction or annulment of the patent.

The owner of an *unpatented* placer claim likewise has the right to possession of the surface within that claim's boundaries for all purposes incident to its use as a placer mining operation. The owner of a placer mining claim, however, does not have any right to veins or lodes that *apex* within the limits of the placer claim. Under the law as enacted and under the various court decisions later developed, the owner of a lode claim has been entitled to all veins or lodes that apexed within the limits of his claim even though such claims might depart outside the vertical plane formed by the sidelines of his claim. The extent of these *extralateral rights* has depended upon the course of the apex of the discovery vein in relation to the boundary lines of the location.

Under the existing location system, *assessment work* consisting usually of an expenditure of at least $100 for labor or improvements must be performed annually upon each unpatented claim by the owner of the claim or at his direction. Failure to make the required expenditure, however, has generally not resulted in the forfeiture of the claim, but has made it subject to relocation by another party. If a contiguous group of claims had been held in common, the assessment work has been held to be valid if done on any one claim, provided that the work is done in connection with a plan tending to develop all claims in the group. The various state statutes have generally provided for the recording of an affidavit of performance of the annual assessment work, and have also usually provided that the recording of the affidavit should be *prima facie* evidence that the work had been performed. Resumption of actual work by the owner of an unpatented mining claim has generally been able to forestall relocation of the ground by another party. An unpatented mining claim has been held to be abandoned only when the owner has voluntarily left the claim and allowed it to be appropriated by another without any intention to retake or reclaim it again. Under the existing system, the Secretary of the Interior has been given the authority to declare a claim invalid by reason of abandonment, but the actual determination of abandonment has been extremely difficult.

Under the existing location system, the procedure used in obtaining a patent to a mining claim consists of several steps, *all assuming that the claim is a valid mineral property*. First, the claimant must file an application in the proper office of the Bureau of Land Management under oath, showing compliance with the law together with a plat and the field notes of the claim or claims showing the boundaries, which themselves must be distinctly marked on the ground. Prior to filing this application, the claimant must have posted a copy of the plat with a notice of his intended application for patent in a conspicuous place on the land designated in the plat. Furthermore, he must have filed an affidavit by at least two persons that such notice had been duly posted, together with a copy of that notice in the appropriate Bureau of Land Management office. When these procedures have been followed, the manager of the land office has then been required to publish a notice of the application for a period of 60 days in that newspaper designated by him as being published nearest the claim and to post a notice in the local Bureau of Land Management office for the same period. At the time of filing the patent application (or any time within 60 days), the applicant has been required to file a certificate that at least $500 worth of labor had been performed or that such is the value of improvements made upon the claim by the applicant or persons under his direction, that the plat is correct, and such further description referring to natural objects or permanent monuments as would serve to further identify the claim. The applicant has also been required to furnish an accurate legal description of the claim to be incorporated in the patent.

Upon expiration of the 60-day period, the claimant has been required to file an affidavit showing that his plat and notice had been posted in a conspicuous place on the claim during the period of publication. If no adverse claim had been filed within the 60 days of publication, it has then been assumed that the applicant was entitled to a patent upon a payment to the proper federal officer of $5 per acre (for lode claims) or $2.50 per acre (for placer claims) and that no adverse claim existed. If an adverse claim were filed, however, its validity has had to be determined by a local court (unless it were waived) before a patent could be issued. At the time of enactment of the Mining Law of 1872, the $5 per acre lode claim fee represented approximately two days' wages for the average mine laborer in the western districts, and the $2.50 per acre placer fee represented about one day's pay. At the same time, skilled miners were receiving wages between $3.50 and $4 per day. Despite all of the above procedures, the issuance of a mineral patent depends at the present time upon the decision of the Department of the Interior as to whether or not the claim involved is a valid mining claim.

3. The Minerals Leasing System[29]

With a few exceptions (namely lead and salt deposits), the tendency in the United States until the beginning of the 20th Century had been to include all minerals under the Mining Law of 1872. Actually, only coal had been included under a separate law that provided for the sale of known coal-bearing lands. This tendency changed sharply early in the 20th Century, resulting from frauds that had been perpetrated in the disposal of coal and oil lands and the problems that had arisen under the mining laws in prospecting for oil. There were also other factors involved in the movement away from the inclusion of all minerals under the Mineral Location Act. These included the growing conservation movement, which was fearful of the dissipation of the nation's natural resources. Perhaps even more of a factor was the growing tendency towards monopoly in the major basic industries (i.e., steel, oil, nonferrous metals) and the resultant fear that all minerals deposits might be acquired by monopolistic producers who then would produce or not produce at their own convenience. Probably the greatest single factor, however, was the increasing importance of petroleum, a mineral far different in geological and physical characteristics from the gold, silver, and mercury around which the Mining Act of 1872 had been designed.

Beginning in 1906, large areas of coal, oil, and phosphate lands were withdrawn from mineral entry under the Mining Act of 1872. Beginning in 1909, laws were enacted providing for the disposal of the surface of public domain under agricultural entries with a reservation of the minerals and the right to remove them to the federal government. Considerable support grew for the disposition of coal, oil, gas, phosphate, potash, sodium, and similar deposits under a leasing system. A leasing law was enacted in 1917 as an emergency wartime measure which provided for the leasing of potash deposits on the public domain. In 1920, the basic minerals leasing law was passed. It provided for the leasing of coal, oil and gas, phosphate, sodium, and oil shale deposits on the public domain. In 1926, a part of this act was extended to include sulfur deposits in Louisiana, and in 1932, it was extended to include sulfur deposits in New Mexico. In 1927, the 1917 Potassium Leasing Act was repealed and the 1920 Act was made also applicable to potassium deposits.

In 1947, the Mineral Leasing Act for Acquired Lands was passed. It provided for the leasing of deposits on acquired public lands of those same minerals that could be leased on the public domain under the 1920 Act. Subsequently, the Secretary of Agriculture was authorized to lease deposits of minerals on acquired lands under the jurisdiction of the Department of Agriculture of minerals that would otherwise be locatable if they had been on the public domain. This applied essentially to those minerals within the acquired lands of the National Forests. Since then, the Secretary of the Interior has also been given the authority to lease *locateable* mineral deposits in certain otherwise withdrawn areas such as the Lake Mead National Recreation Area.

Under the Mineral Leasing Act of 1920, the Mineral Leasing Act for Required Lands, and those other laws providing for the leasing of other minerals on acquired lands and on the National Forests, particularly in Minnesota, there are provisions for both prospecting permits and mineral leases. If the lands are not known to contain a valuable mineral deposit, a *prospecting permit* is issued. This entitles the holder to a *preference right lease* upon showing that he has discovered a valuable mineral deposit. On the other hand, if the lands are known (or strongly believed) to contain a valuable mineral deposit, leasing is by competitive bidding. The issuance of prospecting permits and leases, except for preference rights leases, is entirely discretionary upon the part of the government agency with particular jurisdiction over the land area involved.

Under the leasing system, as currently operating, applications for prospecting permits and leases are processed and evaluated in the local land office of the Bureau of Land Management. The appropriate land office receives from the United States Geological Survey an *opinion* as to whether or not a valuable deposit of a leaseable mineral is contained on the lands for which application has been made. This opinion of the Geological Survey is binding on the Land Office. In addition, the Geological Survey makes recommendations concerning various matters to be included in the permit or lease contract and is consulted by the Land Office manager before any permit or lease is assigned, relinquished, or cancelled.

If the lands for which lease application has been made are under the jurisdiction of an agency other than the Bureau of Land Management (such as the Forest Service), the Land Office will notify that agency of the permit or lease application. If public domain lands are involved, the agency with specific surface jurisdiction will recommend whether or not a prospecting permit or a minerals lease should be issued and will recommend conditions to be included in the lease or permit, if issued. If acquired lands in the National Forests are involved, a permit or lease will not be issued unless the agency having jurisdiction of the surface consents. Furthermore, that agency may insist that conditions imposed by it be included in the permit or lease. In effect, as the system is currently operated for any lands, whether they be public domain or acquired, minerals leases will not be issued nor prospecting permits granted unless the agency which has the jurisdiction over the surface lands is in accord.

When a lease offer on which there will be competitive bidding is made by the Bureau of Land Management for a mineral deposit on lands under the jurisdiction of the United States Forest Service, the Forest Service has the right to issue its own prospecting permit authorizing prospecting under conditions which protect the surface of the land and other natural resources. The Forest Service directly supervises the prospecting operations under such permits, and in addition, supervises operations under both permits and leases issued by the Bureau of Land Management on National Forest land in order to make certain that only activities authorized by the permit or lease are carried on.

The competitive bidding made under the leasing system for lands strongly thought to contain minerals subject to leasing has taken on several dimensions. In some cases, a cash bonus for the awarding of the lease becomes the variable dimension under which the bidding becomes competitive. In other instances, the royalty payment for the mineral has been the variable dimension. When prospecting permits are issued, the permit holder cannot be certain what the terms of the preference right lease (including the terms providing for rent and royalty) will be. These are left to the discretion of the appropriate officer of the Department of the Interior, although minimum amounts are established by statute.

Under the federal leasing systems, the United States retains the authority to supervise minerals exploration, development, and production to a high degree. Most prospecting permits and leases operated under the existing federal leasing system have stipulations and conditions protecting the surface and requiring land reclamation of the areas disturbed by operations under the permit or lease. Under the federal mineral leasing system, leases also provide for a periodic renewal or readjustment of the terms of the lease. At such times of periodic adjustment, the United States (by unilateral action) may revise the rent and royalty provisions and make other changes and additions in the lease. The only remedy available to the lease holder in such a case is an appeal to the Department of the Interior or the surrender of the lease.

Application for a prospecting permit must be filed in the land office of the Bureau of Land Management having jurisdiction over the land involved. All applications under the mineral leasing laws for prospecting permits must contain certain information and must be accompanied by the first year's rental of 25 cents per acre or fraction thereof (but not less than $20) and a filing fee of $10, which is not returnable. Application must be on an approved Bureau of the Budget form and must be filed in duplicate, except for sodium applications which must be filed in quintuplicate. Every application must contain certain specific information including the specific mineral leasing law under which the application is made, the specific mineral for which the permit is requested, a detailed land description showing the total land area in acres, and sufficient data to show that it does not exceed the maximum permitted by law or regulation. All of the land applied for must be within a six-mile square or an area of six survey sections in length and width. Furthermore, the application must include information concerning the applicant himself, such as his citizenship and his current acreage holdings for the mineral for which application is made. If the applicant is a corporation or unincorporated association, the application must include pertinent information concerning the organization's status, including its qualifications to hold a prospecting permit, and information concerning stockholders or members, including their citizenships and individual mineral land holdings. Furthermore, if the application is made under the Mineral Leasing Act for Acquired Lands, the application must denote the specific federal agency from which consent to the issuance of a prospecting permit or lease must be obtained or the agency that may have the title records covering the ownership of the mineral interests involved. An applicant must also identify the project (if any) of which the land is a part. Subsequent legislation has required that in addition to all of this information, an applicant for a prospecting permit must also show whether he owns all of the fractional mineral interests not owned by the United States (or the mining rights therein) for the specific area for which a prospecting permit has been requested. If he does not own all such rights, the extent of whatever rights he may have as well as the names of other owners of such rights must be set forth in the application. The applicant must also submit title evidence of his present interests in the deposit for which application is made. This, it should be kept in mind, is for a prospecting permit on lands not known to contain a valuable mineral deposit.

An applicant for a sodium or phosphate prospecting permit or lease may also apply for a surface use permit for not more than 40 acres (in the case of sodium deposits) for campsites, refining works, and other necessary mineral-related purposes, or for not more than 80 acres (in the case of phosphate deposits) of unappropriated and unentered public land. Such lands are not considered as a part of his lease or permit.

Basically, the four principal mineral leasing systems for nonfuel minerals in operation in the United States today provide first for the issuance of a prospecting permit in areas where there is no known valuable minerals deposits and a competitive lease where the lands are known or believed to contain a valuable mineral deposit. Some of the less inclusive mineral leasing laws that provide only for specific mineral leases have been implemented by regulations that reserve the right to offer a lease by competitive bidding. Under other minor leasing laws, the regulations do not expressly provide that the right is reserved to offer any lease by competitive bidding, but such a right appears implicit under the discretionary authority to lease delegated to the Land Office manager.

4. The Minerals Disposal System

Under the existing laws of the United States, so-called *common varieties* of sand, gravel, stone, pumice, pumicite, cinders, and other minerals not specifically subject to location under the mining laws, or to leasing under the mineral leasing laws, are subject to disposition under the materials disposal system. According to the Materials Disposal Act of 1947, the Department of the Interior has the authority to dispose of all of these minerals found on the public domain except that part of the public domain under the jurisdiction of the Department of Agriculture (i.e., except in the National Forests). The Department of Agriculture has the authority to dispose of these same minerals on the public land under its jurisdiction (see H.A. Twitty and G.E. Reeves, *Legal Study of the Nonfuel Mineral Resources*, p. 903 *et seq.*). Essentially, under the basic statute, the Bureau of Land Management is responsible for the management of saleable mineral materials on the public land except for those materials found in National Forests.

Under minerals disposal legislation of the late 1940's and 1950's, most of the mineral materials subject to this legislation are sold or given away under free use permits. Sales of mineral materials having an appraised value in excess of $2,000 are made by the District Land Office of the Bureau of Land Management, usually subject to the approval of the state director. Most sales of mineral materials, except where very small quantities are involved, must be made by competitive bid after formal advertising. In 1962, however, the provisions of the law permitting sales of mineral materials were revised and negotiated sales are now authorized in certain cases if other specific statutory criteria are met. Limited authority to issue free use permits for mineral materials to state and federal agencies and nonprofit organizations has also been included in the materials disposal legislation.

Under the existing system, *common variety* mineral materials may be sold from the public lands upon the request of an interested party or upon the initiative of the federal government. Basically, the contract purchaser of mineral materials from the public land has the right (for a price) to extract and remove the materials designated until the termination of the specific contract. All sales, whether by competitive bidding or negotiated, are supposed to be made at not less than the appraised value. The materials disposed of under free use permits are an exception to this, of course. Materials offered for sale by competitive bidding are advertised in a newspaper of general circulation in the county where the material is situated. Advertisement is made once if the sale amounts to $5,000 or less, and twice if a value of more than $5,000 is involved. The law and regulations also authorize the public land officer at his own discretion to simply post a notice instead of publishing an advertisement, if the material valued is appraised at less than $1,000.

Under existing regulations, although there are specific conditions that must be met before a negotiated sale may be made, the stipulations in effect give wide latitude to the individual discretion of the designated responsible public land officer. If the contract of sale is for a value less than $2,000, the requirement of a performance bond is within the discretion of the authorized public land officer. If the contract price is in excess of $2,000, a performance bond of no less than 20 percent of the total contract price is required. In addition, the time allowed for the removal of material except that sold under a specific production contract must not exceed two years. One year extensions are, however, possible upon application. Installment sales are permitted and in effect the installments must be paid as the mineral material is removed.

Under the Materials Disposal Act of 1947, as amended, provision is made for the free use of mineral materials for other than commercial or industrial purposes or resale by state and federal government agencies and by any association or corporation not organized for profit. A federal or state agency, unit, or subdivision (including municipalities) may be issued a free use permit without limitations as to the number of permits or as to the value of the materials to be removed. Such permits are to be issued for a term not to exceed 10 years and are not assignable.

Although there are many specific differences in the legislation and in the regulations adopted by the Bureau of Land Management and the United States Forest Service, basically the two systems of mineral commodity disposal used by these agencies are similar, with minor differences occurring in the specific amounts, times, and specific procedures to be followed. In both, extremely wide latitude is allowed to the administrative agency involved in the disposal of mineral materials from the public lands under its jurisdiction.

B. SPECIFIC FEATURES OF THE EXISTING SYSTEMS

1. Discovery Requirements and Assessment Work

Mineral *discovery* has become the critical factor in all of the mineral land systems operating at the present time in the United States. Its importance is most explicit in the mineral location system where discovery has become the all important fact upon which title to a mining claim depends. In the 1860's the rules enforced in the various mining districts in the Western United States recognized *discovery,* followed by appropriation, as the foundation of a mining claimant's ownership of the land and its mineral resources. The Mining Act of 1872 itself provided that ". . .on location of a mining claim shall be made until the discovery of the vein or lode within the limits of the claim located." (See Howard A. Twitty and George E. Reeves, *Legal Study of the Nonfuel Mineral Resources,* Phoenix: Twitty, Sievwright and Mills (1969), p. 366.) Although according to the statute, placer claims did not specifically require a discovery, the discovery of a valuable mineral in-place within a placer claim has been made, through various court decisions, a prerequisite to the existence of a valid claim. In effect, under the present mining law (as enforced), there can be no valid mining claim unless there has been (in the case of a lode claim) a discovery of a vein or lode within the limits of the claim.

The purposes of the discovery requirement were two-fold. The first was to promote the concept that the finder of a valuable mineral should be rewarded for his discovery. This is an ancient tradition. Second, the purpose of the specific discovery requirement in the law was to prevent locations of mineral claims based merely on speculation as to the existence of a vein or lode within the limits of a designated area by persons who simply wished to hold the ground on the chance that it might later prove to have some valuable minerals without their having any real intent to develop the property as a mine, and, of course, also to prevent frauds upon the government by persons attempting to obtain land under the mining laws for purposes other than mining.

What constitutes a discovery has been subject to debate. In legal terms, the existence of a discovery of a valuable mineral on a mining claim is a question of fact, but in reality it has been more a question of opinion. In the 1890's (some 20 or more years after the passage of the Mining Act of 1872), what has come to be known as the *prudent man rule* in deciding what is and what is not a mineral discovery was promulgated. In 1894, it was set forth in a decision regarding a case between two private mineral claimants that

> No right can be acquired to a claim before the discovery of a vein or lode within its limits; but the finding of ore or metalliferous rock in-place in a defined vein is sufficient to satisfy the statute, although it does not contain ore in paying quantities. If the rock in-place is sufficiently encouraging to warrant an ordinarily prudent man in spending his time or money upon it, it is sufficient, as against a subsequent locater for mining purposes.

(See Twitty and Reeves, *op. cit.,* p. 388.) In other words, for a mining claim to be valid it has been held that there must be something more in it than mere traces or slight indications of ore minerals which might give rise to undue speculation or conjecture that mineral in commercial amounts might exist on that land. Whether any such traces or indications would constitute a discovery then depends on whether they are sufficiently encouraging to warrant an ordinarily prudent man's spending his time and money upon it in the expectation of finding mineral of sufficient grade and in sufficient quantities to be commercially useable. As has been indicated in previous chapters, there are a number of factors that enter into the determination of what a prudent man would do under various circumstances of mineral discovery. Among these factors are the geology of the area in which the *discovery* is made, the location of other known mines or mineral deposits in the area, the history of the development of other mines in the area, the various economic factors related to the cost of production and sale of the finished commodity, and the necessary steps that must be taken in developing the claim as an operating mine.

In disputes between a mineral claimant and the United States Government, however, other criteria are used in determining whether or not a *discovery* has been made in the light of the Mineral Location Act of 1872. First of all, the land in question must be considered *mineral in character,* whatever that may be. Early decisions of the Secretary of the Interior, in administering the law, held that before land could be considered as mineral land, it had to be shown that the land contained mineral in such quantities to make it available and valuable for mining purposes, i.e., that a *discovery* of a mineral deposit had been made, and that the mineral could be secured at a profit by the usual methods of mining. Thus, the fact that land might contain visible particles of gold did not necessarily make that land mineral land unless it also appeared that it contained gold in such quantities as to make it valuable for mining purposes.

Through a long series of court decisions and decisions by the Secretary of Interior, what has become known as a *marketability concept* regarding *discovery* has developed. In reality, this appears to require that the *profitability* of a potential mining operation must be in evidence before a showing of a valuable mineral in-place can be considered a *discovery.* At the present time, it appears that for a mineral *discovery* to have been made, the mineral found must be capable of extraction and sale at a profit to the developer and seller. The entire structure of what is and what is not a mineral *discovery*, however, is still rather ambiguous and open to varying interpretation.

Discovery of a valuable mineral is not entirely the concern of only the minerals location system. *Discovery* is also a critical factor in the minerals leasing system. Under the issuance of prospecting permits for leaseable nonfuel minerals, there is a provision that the permit holder may apply for a preference rights lease, if he *discovers* valuable deposits of the leaseable minerals covered by the permit within the permit area and within the other terms of the permit as issued. *Discovery* of a valuable mineral deposit thus becomes a prerequisite for a preference rights lease under the minerals leasing laws or under the regulations that implement those laws and which authorize the issuance of prospecting permits. (See Twitty and Reeves, *op. cit.*, p. 780.)

Even under the Materials Disposal Act of 1947 (and as amended in 1955), the *discovery* of a valuable mineral is important. Under the mineral commodities disposal system, however, *discovery* is implicit. In other words, the existence of a valuable mineral commodity has already been determined; the deposit has already been *discovered,* and prior *discovery* thus becomes a part of this system as well.

The chief concern of the *discovery* principle, however, is still in the minerals location system. With considerable latitude open under the Mining Act of 1872 to the various state legislatures for the formulation of specific requirements, regarding *discovery* and *discovery work,* there has been considerable variation. Nevertheless, on one point, all of the state laws in the 11 Western States are in agreement. That is, that a *discovery* marker must be placed on each mining claim. Most of the state laws call for the erection of a monument at the place of *discovery,* along with a conspicuously posted notice, also at the point of *discovery,* containing the name of the locater, the name of the vein, lode, or claim, and the date of location. In every one of the 11 Western States, then, a physical indication of the *discovery* of a valuable mineral on the ground is required. Beyond this, however, state requirements begin to differ. The methods of providing evidence of a mineral *discovery* and the time in which such work can be done vary from one state to another, although there is a general range in which all of the variations fall. In California, for example (the state in which the original claim system was developed in the local mining districts), within 90 days after the date of location (i.e., *discovery*) of a lode or placer in a particular area, it is required that a *discovery shaft* (at least 10 feet deep) be sunk, or that a tunnel, adit, or open cut at least 10 feet deep be excavated. Where an association placer claim is involved, the California statutes require that one shaft or tunnel be driven for each 20 acres contained in the entire association claim. In recent years, this *discovery shaft,* or *discovery pit* requirement, has been amended to include a drillhole (not less than 25 feet deep) made by equipment capable of collecting and bringing to the surface a sample that may actually be inspected or physically tested. The drilling of discovery holes in one place for several associated or several adjacent claims has been made possible in California, but nevertheless some excavation, either by the driving of a tunnel, a shaft, or a pit, or by the drilling of a hole from which a sample may be extracted, must be performed within 90 days of the initial date of *discovery*.

Most of the Western States have similar requirements for the performance of *discovery* work either at the time of or immediately after the initial location of a mining claim. Several states, such as California, grant 90 days in which to do this work. These include Nevada and New Mexico. Other states require that such work be done within 60 days. These include Idaho, Montana, Colorado, Oregon, Washington, and Wyoming. In Arizona, 120 days are permitted from the time of location in which to sink a *discovery* shaft eight feet deep or to drill a hole 10 feet deep in any one claim, as long as the total amount of work done is valued at $100 or more per claim. The Arizona requirement specifically designates core drilling as the accepted means of *discovery* drill work. In most states, no *discovery* work is necessary on placer claims. In Idaho, however, *discovery* work on a placer claim must be performed within 15 days of the initial location. This is an exceptional requirement as far as the Western States are concerned.

Just as the times at which *discovery* work must be performed vary from 15 days (for a placer claim in Idaho) to 120 days (for a lode claim in Arizona), so also do the types and values of actual discovery work necessarily vary. As has been noted, in some cases shafts, pits, or tunnels of varying sizes must be driven. In other states, exploration holes may be substituted for this discovery pit requirement. The acceptance of drillholes as meeting the work requirement for mineral *discovery* are fairly recent in most states where they have been adopted. In Washington, the statutes specifically state that there shall be no discovery shafts driven west of the Cascade Mountains. Most of the states require excavations in some multiple of 10 feet, either in depth, width, or length. There are also variations in the size and depth of drillholes required to meet the discovery provisions of the various state laws.

The *discovery* requirements and assessment work provisions of the various state laws, as well as the overall *discovery* requirements of the federal laws (under all three systems, but more specifically under the mineral location system), in effect imply that the *discovery* of a valuable mineral deposit is a single event, an occurrence that is definable within a specific and usually very short period of time. This has never been consistent with geologic or technical reality and certainly not with current exploration and mineral development practice. In truth, under existing conditions and under conditions as they are likely to be for the next decade or two, the *discovery* of a valuable mineral deposit is not a single event but a sequence of events, a process, that may be stretched over 10 years or more. Furthermore, such *discovery* is not dependent upon actually seeing a particular mineral in-place in the ground, but is really not ascertained until all factors, geologic, technological, and economic, as well as legal and political, are balanced in appropriate manner to constitute the existence of a valuable mineral deposit. For example, the discovery in a single drillhole of copper minerals, which may contain as much as five percent copper over a length of even as much as 100 feet, does not really constitute the *discovery of a valuable mineral deposit*. It does, however, constitute the *discovery of a valuable mineral* in-place. Only after numerous drillholes have *discovered* similar valuable minerals over an adequate area could it be said that a valuable mineral deposit has been discovered. Under present conditions, then, the discovery of a valuable mineral deposit is a process, a sequence of events, and not a single event.

2. The Size of Claims and Leases

Under the existing mineral location system, a lode claim may not be more than 1,500 feet in length and 600 feet in width, defined as a maximum of 300 feet on either side of the vein discovered within the claim. These are maxima and the locator of a claim is not required to define a lode claim of the full length and width allowed by the law. He may locate a smaller claim if he so desires, and he may also define a claim which is not rectangular in shape. This has led to the widespread practice of filing *fractional* mining claims, claims that have been filed in irregular shapes so as to take up unclaimed ground between the rectangular claims of other persons. Under the Mining Act of 1872, placer claims were required to be substantially rectangular in form, oriented toward the public land survey where possible, and limited to a maximum size of 20 acres. Nevertheless, association claims filed by eight persons, and up to 160 acres in total size, are permitted.

Under current conditions of mining technology and the types of mineral deposits now in use, a single lode mining claim of approximately 20 acres is not adequate for the proper development of a mineral-producing operation. In fact, most operations in use today consist of many claims placed side by side and end to end over wide areas. Since 1947, only the smallest uranium operations have been possible on areas less than 20 acres in size. Virtually all other mineral-producing operations require far more than 20 acres. The same is true of the five acre limitation on a mill site claim. Five acres is no longer adequate for the types of surface facilities necessary for the effective mining of any but the smallest mineral deposits of extremely high unit value. Only very small beneficiating plants in the early days of the first uranium rush in the 1950's could be accommodated on a plot of five acres. Most existing beneficiation plants require far more than this amount of land.

There are two kinds of acreage limitations under the mineral leasing laws. One is a limitation on the acres that may be included in the prospecting permit or lease, and the other is a limitation on the total acreage that one holder may have in any one state or in the nation. The nation is the relevant unit with respect to phosphate permits and leases, while the individual state is the relevant unit in the case of sodium and sulfur leases. Acreage limitations involved under the Mineral Leasing Act of 1920, however, are not chargeable against acreage limitations under the Mineral Leasing Act for Acquired Lands, or vice versa. When the Mineral Leasing Act of 1920 was originally enacted, it provided that the total acreage of each prospecting permit or lease for sodium and each lease for phosphate could not exceed 2,560 acres. Furthermore, it specified that a permit holder or lease holder could not obtain more than one permit or lease for each mineral in any one state.

In 1926, the Mineral Leasing Act was extended to include sulfur lands in Louisiana, and the acreage limitation on leases and permits for sulfur was set at not more than 640 acres for each lease or permit. The amended statute also prohibited any person, association, or corporation from taking or holding more than three sulfur permits or leases in any one state at any one time. Later, when the Mineral Leasing Act was extended to New Mexico, the acreage limitations for sulfur were not changed, and today they remain as the effective area limitations applicable to sulfur leases in both Louisiana and New Mexico.

When the Mineral Leasing Act was extended to potassium permits and leases in 1927, each prospecting permit or production lease could not exceed 2,560 acres, and this acreage limitation remains in effect today. Unlike the other three leaseable nonfuel minerals, however, there is no statutory limitation on the total non-contiguous acreage that one person or corporation may hold under potassium leases and prospecting permits. Nevertheless, by *regulation,* a potassium acreage limitation has been fixed at no more than 51,200 acres under prospecting permits in any one state and no more than 25,600 acres under lease in any one or more mining units. Upon application, however, certain fringe area deposits not exceeding 2,560 acres may also be held without an appropriate acreage charge.

The subsequent enactment of the Mineral Leasing Act for Acquired Lands permitted an increase in the total acreage holdings allowed to one person for certain minerals. On acquired lands, a person, association, or corporation may take or hold sodium leases or prospecting permits of no more than 15,360 acres in any one state when it is determined that such an acreage is necessary in order to secure the economic mining of a leaseable sodium compound. An individual, association, or corporation is not subject to any *statutory* acreage limitations on leases and permits for potassium, but, by *regulation,* the acreage limitation on such leases in any one or more mining units has been set at 25,600 acres with a provision that an additional 2,560 acres of fringe acreage may be added to the maximum lease acreage upon the showing of a need for such addition. The *statutes* provide that no person, association, or corporation may hold phosphate leases or prospecting permit with an aggregate area of more than 20,480 acres in the United States. The *regulations* similarly provide, however, that a phosphate lease holder may obtain (within his statutory limitation) an additional acreage not exceeding 2,560 acres if it is determined by the appropriate land office manager (after consultation with the regional mining supervisor of the United States Geological Survey) that the increased acreage will result in the conservation of natural resources by allowing the most efficient utilization of the mineral deposit in question. (See Twitty and Reeves, *op. cit.*, p. 753.)

Under the minerals leasing system, all land included within a single prospecting permit or mineral lease must be within a six-mile square or within an area of six surveyed sections in length or width (36 sections total). Regulations under leasing laws which specify smaller leasing units provide that the acreage shall be in a reasonably compact form or shall consist of such area of land as shall be determined by an authorized officer of the Department of the Interior to constitute an economic work unit. Under the leasing system, then, the actual size of area involved in any one prospecting permit or lease is variable. In general, permits and leases may exceed the maximum acreage established by either law or regulation when such excess is within what is known as the *rule of approximation*. This regulation, formulated under the Minerals Leasing Act of 1920, states that a larger area may be granted under the *rule of approximation* in those states covered by the public land rectangular survey system and that this rule applies to prospecting permits only where the elimination of the smallest legal subdivision involved would result in an area significantly less than 2,560 acres, which is the prospecting permit acreage limit, and significantly greater than 2,560 acres if such a subdivision were included.

The effect of all the statutes and regulations is basically that for phosphate production, the acreage limitation on a lease or prospecting permit is 2,560 acres and the total acreage under lease or permit that may be held by one individual is 20,480 acres in the United States. For sodium minerals, 2,560 acres is the limitation for any one lease or prospecting permit, and no more than 5,120 acres may be held by one person in any one state except at the discretion of the Secretary of the Interior. At his discretion, one person, corporation, or association may lease up to 15,360 acres in any one state. For potassium minerals, the maximum acreage allowed for a single lease or permit is 2,560 acres; no more than 51,200 acres may be held in prospecting permits by any one person, corporation, or association in any one state; no more than 25,600 acres may be held under lease in any one mining unit, except upon application; and *fringe area* deposits may not exceed 2,560 acres beyond this. For sulfur minerals, the size limitation for a single lease or prospecting permit is 640 acres, and no more than three permits or leases may be held by any one individual in any one state. (See Twitty and Reeves, *op. cit.*, p. 753.) These legal limitations have had definite effects on mineral resource development, as shown by Tables 12 and 24 in Volume II.

Under the materials disposal system, there are no acreage limitations, as such. The maximum acreages defined as in the minerals leasing system and not defined in the materials disposal system are much closer to existing economic, technical, and geologic reality than are the area limitations superficially imposed in the mineral location system. Of course, under the mineral location system there really are no maximum areas, because there are no longer any limits to the numbers of claims that can be filed or located by any one person, corporation, or association. The limitations under the location system are simply on the size of the individual claim.

One feature of the mineral location system as currently in existence provides even greater latitude than the practice of using groups of claims. Although the surface area may be limited on any one claim, the subterranean extent of a vein or lode contained on a claim is not limited. Under the *apex rule* and the principle of *extralateral rights*, the holder of a claim at the highest point (the apex) of a vein has rights to that vein even though it may extend beyond the vertical planes formed by the side lines of his claim. Thus, the extent of *mineral rights* can extend beyond the maximum claim width of 600 feet. Under the existing system as actually practiced in the industry, however, *extralateral rights* have become almost nonexistent. Certainly, where the geologic structure containing a valuable mineral deposit is not a vein or lode, the principal is no longer valid, even academically.

3. Duration of Mineral Lease Tenure

Both the Minerals Leasing Act of 1920 and the Minerals Leasing Act for Acquired Lands provide that the term of a prospecting permit shall be two years for phosphates and not in excess of two years for sodium, potassium, and sulfur. No extensions of a prospecting permit are granted in the case of sodium or sulfur, although phosphate prospecting permits may be extended for an additional period not to exceed four years. If it is found that a prospecting permit holder has not been able (after excercising reasonable diligence) to determine the existence or workability of phosphate deposits in the area covered by his permit, and if he wishes to continue further prospecting or exploration, an extension may then be granted. Under legislation passed in 1932, a prospecting permit for potassium may be extended for a period not more than two years, if there is a showing of satisfactory cause for extending that permit.

All nonfuel mineral leases are subject, either by statute or by regulation, to unilateral periodic adjustment in royalties and in other terms and conditions by the government. The statutes themselves do not specifically provide for fixed lease terms, but the regulations that have been developed by the various administrative agencies do. For so-called *hard rock minerals* on acquired lands, the statutes provide that the lease will be for a period of no more than 20 years. Nevertheless, shorter term leases may be involved. The same is true for leases on National Forest lands. In some other places, the statutes provide for leases for a maximum term of five years, subject to renewal for additional periods of five years each. (See Twitty and Reeves, *op. cit.*, pp. 803-806.) Since each minerals lease is a separate agreement between the lease holder and the United States Government, the variation, of course, in the terms of tenure are highly variable, and only the broadest maxima have been set. Furthermore, because the terms of any lease may be changed unilaterally by action of the federal government on extremely short notice, in effect, any one lease provides tenure only for the duration of that prior-notice period. As a result, under the mineral leasing system as it is in effect today in the United States, the actual duration tenure by the mineral resource user can be extremely short. The same is true under the mineral commodity disposal system. To the contrary, under the minerals location system, the tenure of the mineral land claimant becomes permanent (if patent can be obtained to the mining claims sought) or virtually nil (as against the government, but permanent as against another private individual) in the case of an unpatented mining claim. None of these variations, except for the patented mining claim's permanent tenure, appear to be consistent with technical, economic, or geologic reality.

4. Environmental Protection Provisions

Most of the environmental protection features of the existing public land systems for nonfuel minerals are found under the leasing and materials disposal systems. Within the minerals leasing system, prospecting permits invariably contain regular provisions that require the protection of the surface and other natural (other than mineral) resources. In addition, there are usually environmental control conditions and stipulations (and often even supplemental conditions and stipulations) that may be made a part of any prospecting permit at the option of the federal government. Furthermore, although such provisions may not formally be a part of any existing prospecting permit, all federal regulations on surface exploration, mining, and land reclamation are now applicable to any new permits issued.

Provisions in mineral leases go well beyond what is normally thought of as the natural environment in establishing certain provisions for the welfare and safety of those involved in mining operations and also for the possible effects of mining operations on economic conditions. According to statutes enacted prior to World War II, every mineral lease must contain provisions requiring the operation of the lease in a professional and customary manner. More specifically, there must be provisions for the protection and safety of the miners employed in the operation. There must also be provisions for the general welfare of the miners including the hours in which they are allowed to work underground.

Furthermore, (and this is directly related to the economic environment), there must be provisions in the lease for the protection of the general public in such matters as the prices charged for the mine's products and to assure protection from monopoly. All of these provisions were stipulated as necessary for a mineral lease under the Mineral Leasing Act of 1920, well before the extensive social legislation of the 1930's and 1940's.

Particularly stringent provisions regarding the environmental effects of mining operations are contained in those leases for minerals found on lands administered by the United States Forest Service. The Forest Service Manual is very specific in stating that "strip mining, rim cutting or any similar form of mining that destroys the surface or removes the topsoil" will be approved only if an analysis of the effects of that mining operation shows it to be in the public interest and in accord with the Forest Service's strip mining policy. Most of the regulations of the Forest Service are similarly vague, while others are extremely specific in providing for the exact procedures to be followed in land treatment both during and after mining operations have been terminated in a given area. *The implication throughout most of the Forest Service regulations and specific lease provisions is that mineral industry activity is the worst possible use of the public lands.* In virtually all instances, on the National Forest and on other public lands as well, considerable latitude is left to the local or regional contracting agency in specifying the exact nature of environmental control provisions to be included in each lease or prospecting permit agreement.

The primary concern of most of the environmental control provisions in mineral lease agreements, commodity disposal contracts, and prospecting permits to date appears to have been the condition of the land itself and its vegetation. Provisions for relationships to be maintained between mineral activities and the water resources of the environment are also included, however. For example, mineral locations or entries on public lands withdrawn as public water reserves can only be made subject to a primary right of public use for watering purposes. Another specific instance of concern for water involved Death Valley National Monument, where on any legal subdivision of the land containing a spring or waterhole (or within one-quarter of a mile of a spring or waterhole on unsurveyed public land), construction, development, or dumping on any mining claim is prohibited. Under the Federal Water Pollution Control Act, however, the individual states were given the responsibility of adapting water quality criteria that would be applicable to interstate waters within their borders, and also for planning the enforcement of the water quality criteria adopted. A principal responsibility for maintaining water quality on the public lands and other lands of the United States was given to the Secretary of the Interior, and a procedure was established for the adoption of water quality standards for any state that either failed to develop its own water control standards or did not adopt standards acceptable to the Secretary of the Interior. Although the Secretary of the Interior was given the authority to enforce water quality standards, primary initiative was given to the individual states. This is true even for waters on the public lands.

The Air Quality Act of 1967 placed atmospheric quality under the jurisdiction of the Secretary of Health, Education, and Welfare, and the initiative for the adoption of air quality standards and enforcement measures was made the primary responsibility of the federal government, rather than the individual states. Neither the federal Water Pollution Control Act nor the Air Quality Act of 1967, however, are specifically applicable to mineral resource activity only on the public lands. The two measures operate either through the states or through the specific federal agency designated with authority in each case and generally not through the public land laws or through the administration of leases, prospecting permits, mineral patents, or commodity disposal contracts. The potential for the use of such instruments in enforcement of these laws is extremely high, however.

5. Terms of Payment

Under the minerals locations system, the purchase price of a lode claim is set at $5 per acre or fraction of an acre. The purchase price of a placer claim is $2.50 per acre or fractional part thereof, plus $5 per acre for any vein or lode included within the boundaries of the placer claim, together with 25 feet of surface on either side of the vein or lode. These are not the only charges, however, involved in patenting mineral land under the mineral location system. There is also a service charge payable to the Bureau of Land Management for filing and acting upon an application for mineral patent. This charge, amounting to $25, is not refundable and must be paid by the applicant at the time of filing his application. The applicant for mineral patent is also required to pay the costs of the mineral survey of the land and the publication notices. These frequently amount to much more than the fees established by statute for the purchase of public lands under a mineral patent. For example, in establishing an acceptable survey for a single claim, minimum costs of $100 to $300 are common in the Southwest, where surveying conditions are relatively easy. In the northern Mountain States and in the Pacific Northwest, where vegetation cover is greater, surveying costs tend to be higher.[3]

Under the mineral leasing system, several payments are made for the mineral use of the public lands. Under the competitive bidding system, there is normally an initial bonus paid to the government at the beginning of the lease. There are also rental payments to be made for the land itself, and there are royalties to be paid, based on the volume of production. Until there is production, the rental under a mineral lease is paid to the local land office of the Bureau of Land Management. On producing leases, however, the rental is paid to the appropriate mining supervisor of the United States Geological Survey. Under the Mineral Leasing Act of 1920, each year's rent is credited against royalties that accrue for the year, so that, in effect, the rental becomes a minimum royalty. The rental rates vary, however, depending upon the mineral involved in the lease. For sodium and potassium leases, the rental is 25 cents per acre (or fraction thereof) for the first calendar year of the lease. The rent rises to 50 cents per acre for the second, third, fourth, and fifth calendar years of the lease. For the sixth and every subsequent calendar year, the rental is $1 per acre. Under phosphate leases, the rental is again 25 cents per acre for the first calendar year or fraction thereof. It also rises to 50 cents per acre for the second and third calendar years. In the fourth calendar year, however, the rental on a phosphate lease rises to $1 per acre and remains at that rate for each year thereafter. For sulfur leases, the rental charge is a flat 50 cents per acre per year regardless of the age of the lease. These rates apply to mineral leases on both public domain and acquired lands. For other minerals on acquired lands, a minimum rental of $1 per acre is charged. (See Twitty and Reeves, *op. cit.*, p. 807.)

Leases for all nonfuel minerals included under the Mineral Leasing Act of 1920 provide that royalties should be paid to the appropriate regional mining supervisor of the Geological Survey once the lease becomes productive. The amounts of the royalty charged are variable. Under the Mineral Leasing Act of 1920 and the Mineral Leasing Act for Acquired Lands of 1947, there is, however, a statutory minimum that must be charged. In the case of phosphates and associated minerals, the royalty must be not less than five percent of the gross value of the output. For sodium and potassium minerals, the royalty must be not less than two percent of the quantity or gross value of the output of the mineral compound and other related products at the point of shipment to market. In the case of sulfur, a royalty of five percent of the quantity or gross value of the output of sulfur at the point of shipment to market is the minimum. With respect to hard-rock minerals (i.e., minerals other than those mined primarily for their sodium, potassium, phosphate, or sulfur content), the basic mineral leasing law provides that, on acquired lands, the Secretary of the Interior may establish reasonable minimum values in order to compute royalties on any leased deposit. It should be noted that in the case of three of the leaseable nonfuel minerals (sodium, potassium, and sulfur), at the option of the government, the royalty may be paid in kind rather than in cash. Of course, prior notice must be given of such a change in requirement to the minerals producer with a significant period of anticipation. Under the leasing of minerals under the Atomic Energy Act of 1954, leases are generally awarded only to the acceptable bidder offering the highest cash bonus. This, of course, puts an infinite ceiling (actually no legal ceiling) on the size of a cash bonus. A minimum amount is implied, however, because the federal government has the right to reject all bids. Royalties are variable and are at rates specified in invitations to bid. Mineral leasing regulations implementing other relatively minor legislation, establish a minimum royalty of two percent of the gross value of the minerals produced.

Materials sales made under the commodity disposal system are normally offered for competitive bidding and are usually advertised in newspapers of general circulation in the county where material is located. Since a competitive bidding situation is usually involved, the prices paid for the minerals so disposed of are quite variable. The statutory stipulation that no commodity may be sold for less than its appraised value tends to place a minimum on the prices paid, however. Under the sales of minerals materials under the commodity disposal system, a cash deposit must accompany bids for cash sales. This deposit must be 10 percent of the appraised value of the mineral materials to be removed. With bids for installment sales, it must be not less than the amount of the first installment as required by regulations and specified in the advertisement for sale. If any contract price is less than $2,000, the requirement for a performance bond is left to the discretion of the authorized contracting officer. If the contract price is in excess of $2,000, however, a performance bond of not less than 20 percent of the total contract price is required. Payments on a contract of $2,000 or less must be made upon the execution of the contract. Payments on contracts in excess of $2,000, however, may be made in installments. Under such an installment arrangement, payments are made throughout the duration of production. Sales of all mineral commodities in a specified area that exceed $2,000 must be conducted on a specific installment basis. The first installment of not less than $500 must be paid upon execution of contract, and the remaining installments (in amounts specified by the contract) become due and payable without notice whenever the estimated value of the mineral material removed equals the sum of the installment that had been paid to that date. In other words, no more material may be removed than has been paid for.

6. Rate of Recovery Requirements

Under the mineral location system, there are no production rate requirements nor rate of recovery requirements applicable to any mineral deposit on lands that have been patented. Nor are there any such requirements with respect to the volume of production from unpatented mining claims. The only work requirements contained in the minerals location system refer to mine development work and not to mineral production. Furthermore, in most cases, statutory work requirements are tied to value dimensions rather than to specific types or quantities of work defined in physical units. The only exceptions to this are the linear dimensions required by various state laws for discovery pits on new claims. On patented mining claims, of course, there are no production requirements (after patenting), either in value terms or physical units.

Under the minerals leasing system, nonfuel minerals leases require that production must begin by a prescribed date, except when operations may have been interrupted by strikes, adverse weather conditions, or other reasons not the fault of the lease holder. The time within which production must be started varies from one commodity to another. For sodium, sulfur, and potassium, the time prescribed is in effect five years, or before the beginning of the sixth year of the lease. For phosphates, the time within which production must be begun is three years, that is, before the beginning of the fourth year of the lease. For other mineral leases on acquired lands, the time within which production must be begun varies from one specific lease to another.

All of the production initiation time intervals in minerals leasing are attached to a minimum production figure. This minimum production figure is also variable from one lease to another. All of the lease forms used provide that the failure on the part of the lease holder to begin and maintain production at the minimum rate provided in the lease makes the lease holder liable for payment of the minimum royalty stipulated in the lease. (See Twitty and Reeves, *op. cit.*, p. 848.) The penalties for not meeting the minimum production requirements (either in volume or within the prescribed time) are essentially financial, in that the schedule of rentals and rentals which may be charged against royalties increase, after the fifth year for potassium, sodium, and sulfur minerals, and after the third year for phosphate minerals. Although there are provisions in the system for rescinding leases and cancelling contracts, the increase in the amount that must be paid for the land under lease is, in effect, the penalty for not meeting the prescribed production requirements. Although under the minerals leasing system, there is substantial supervision of mining operations by the Geological Survey, percentage rates of recovery of minerals from a given mineral deposit are not specifically spelled out. Nevertheless, mining plans and operations must be approved by the Geological Survey, and these have a direct bearing on rates of production and recovery.

7. Acquisition Provisions

Basically, under the three existing systems of public land mineral policy, the minerals on the public lands may be acquired in three ways. They may be purchased, as under either the commodity disposal system or the mineral location system. The difference between purchase under the two is that by mineral location, the lands as well as the minerals are purchased from the federal government, while under the commodity disposal system, the minerals only are purchased from the federal government and must subsequently be removed from the land.

Another manner in which minerals may be acquired from the public lands by private interests is through lease under the minerals leasing system. Under the federal system, as it exists, this is a lease without any options on the part of the private lease holder, but with virtually all options on the side of the federal government. It is not a lease with option to buy, as is most often the case under private land systems. In effect, the provisions of the current mineral leasing legislation (despite the fact they are called a leasing system) amount to a combined rental of the land and a purchase, on a percentage of total value basis, of the minerals as they are removed. Under the leasing system, there are also two variations in the manner in which minerals may be acquired from the public lands. The first is under a prospecting permit which, upon discovery of a valuable mineral deposit, can result in a preference right lease. The other is through the acquisition of a minerals lease by competitive bidding. This is in contrast to most private mineral systems where *open* competitive bidding is normally not involved. Under private systems, a situation much more akin to a prospecting permit, with a preference right lease (or an option to lease), is the more normal situation.

There is a third method by which minerals on the public domain may be acquired by private interests. This is a variation under the mineral location system in which land is not brought to patent, but under which production is maintained from unpatented mining claims. In effect, under this method of acquisition, there is no direct return to the federal government for the minerals acquired for private use, the only governmental charge being the required cost of filing a mineral location notice and appropriate affidavits. This revenue, of course, goes to the county government with jurisdiction over that particular locality and not to the federal government. Unless mineral claims are patented, there is no *direct* revenue received by the federal government for the use of these mineral resources. Under this type of mineral acquisition, then, the minerals are appropriated for the cost of finding, developing, and producing them. Such production, of course, is likely to result in tax revenues to the federal government, but these are not directly related in quantity with the extent of the public lands involved.

8. Land Withdrawal Provisions

Since the late 1800's there have been numerous land withdrawals and mineral reservations, both by the Congress and by the various agencies of the Executive Branch, that have closed certain types of lands to mineral location or leasing or both. In addition, some states have withdrawn land from mineral entry. In some instances, although lands have not been closed, significant restrictions have been imposed upon mineral location or leasing effecting the withdrawal of certain lands. Among the types of lands that have been affected by withdrawal action are lands containing hot springs or geothermal steam resources, lands containing water holes (particularly in arid areas), stock driveways, military reservations, Indian reservations, public power sites, reservoir sites, recreation areas, wildlife refuge areas, wilderness areas, and certain other specific lands withdrawn for specific purposes or because of specific legal problems involved in their use. In these last categories are certain grant lands in Oregon and California. In addition to the actual withdrawal of certain areas from the mineral location and leasing systems, the creation of the mineral disposal system in the late 1940's and 1950's also had the same effect. For example, the Multiple Surface Use Act of 1955 removed the so-called *common varieties* of sand, gravel, pumice, pumicite, and cinders from the jurisdiction of the mining location system and also from the mineral leasing system.

While most of the withdrawals of public lands from mineral utilization under any one of the three mineral use systems have been the responsibility of the Secretary of the Interior, the United States Forest Service has also been involved in such withdrawals. On frequent occasion, the Forest Service has initiated action to have both public domain land and acquired lands within the National Forests withdrawn from mineral leasing as well as from mineral location. When specific criteria (which are rather broad) have been met, it has been possible to withdraw from mineral leasing certain lands set aside for special purposes, such as wilderness or primitive areas, or lands associated with special utilization of the surface resources, such as city watersheds. Lands used for special purposes or programs, such as experimental forests or experimental ranges, and lands planned for future special use or development have also been withdrawn. It has generally not been the policy of the Forest Service to request withdrawals for relatively small areas, such as those used for road construction, developed campgrounds, or small scenic or recreation areas. Formal withdrawals of such areas have not been necessary because effective withdrawals have been made by the Forest Service itself through adverse recommendations on any relevant lease offer or prospecting permit application. Nevertheless, some problems have arisen from the failure of the Forest Service to withdraw such lands from mineral utilization under the mineral location system. In cases where such problems have developed, the lands in effect had been previously withdrawn, often by rather informal and irregular methods. These include restriction of access to mining claims and the imposition of severe restrictions on the use of surface resources by mine claimants, as well as general harrassment.

Under the Materials Disposal Act of 1947, there have been some withdrawals from mineral use of certain lands under the jurisdiction of the Department of the Interior. Under this legislation, the sale of mineral materials or the disposal of mineral materials from lands included in the National Parks, National Monuments, and Indian Reservations has generally been prohibited. Nevertheless, the same Materials Disposal Act of 1947 has provided that disposal of mineral commodities may be made from withdrawn lands under the jurisdiction of the Department of the Interior, if they have been withdrawn in order to aid a function of a federal agency (other than the Department of the Interior) or assist a state, territory, county, municipality, water district, or other local government or subdivision thereof. Such sales are allowed, of course, providing that the government or agency for whose benefit the withdrawal was made in the first place gives its consent to the removal of such mineral materials from that land. The same is true of withdrawn lands under the jurisdiction of the Forest Service. The Forest Service has, in fact, made agreements with the Federal Power Commission, the U.S. Army Corp of Engineers, and the Bureau of Reclamation, permitting limited mineral disposals from lands withdrawn for the purposes of those agencies. (See Twitty and Reeves, *op. cit.*, p. 921.)

Generally, land within all National Parks and Monuments has been withdrawn from mineral entry under any of the three mineral utilization systems for the public lands. Exceptions to this are certain lands in Olympic National Park, Mount McKinley National Park, Death Valley National Monument, Glacier Bay National Monument, and Organ Pipe Cactus National Monument. The revested Oregon and California Railroad lands and the Coos Bay Wagon Road grant lands have also been effectively withdrawn from mineral entry by designation of those lands for other permanent surface uses. Even though specific national parks and monuments are legally open to mineral entry, in many respects administrative procedures and regulations adopted by the Department of the Interior have kept those areas withdrawn from mineral entry for all practical purposes. In other instances, although the lands are open for exploration, production possibilities are doubtful.

9. Resource Information Provisions

Under the mineral location system as presently in existence in the United States, the amount of information about the public lands which must be provided to the federal government by an actual or potential resource user is rather sparse, even when an application is made to patent any particular mining claim. Prior to patenting, however, there is in effect no requirement that any information at all be provided to the federal government, but only that a bare minimum of information be recorded in the county in which the claim is located. In fact, these information requirements are governed more by state law than by federal law. In most instances, not even an accurate description of a claim's physical location is necessary, in that it is not required that a specific unpatented mining claim be related to any particular fixed government survey point, but only in general terms to a prominent local physical feature or structure. As a result, claim location descriptions containing information such as "500 yards more or less southwest of an old stone building" or "300 yards northeast of the top of Mount Whatchamacalit" have become common. In fact, the local recording of an unpatented mining claim gives no information other than that, within a given county, there is interest in the mineral resources of the public lands. Even that may not necessarily be true, however, since the interest may be more in the surface value of the land than in the mineral resources contained therein. This lack of definite informational requirements for unpatented mining claims has caused serious problems for all users and potential users of the public lands.

Under the mineral location system, in order to obtain a patent on a particular mining claim, the information to be provided to the federal government must be more specific than that provided for an unpatented mining claim. Nevertheless, even the patenting procedures do not provide much information regarding the mineral resources themselves. Essentially, the information required in a patent application includes a specific survey. In other words, the application must give the specific location of the mining claim and, wherever possible, tie it into public survey markers. Information must also be provided in regard to the amount of work done by the applicant on the claim itself and the mineral character of the land in question. In actuality, the extent of such information required is whatever is needed to satisfy the Department of the Interior that the land is mineral in nature and that *bona fide* mineral development work has been undertaken. This can be extremely variable and dependent entirely upon the humor of the Department of the Interior. Under the most recent court decisions, it appears that full-blown economic feasibility studies for the development of a mineral property would be necessary before a patent could be granted. In previous years, relatively simple assay or geologic data were sufficient.

Under the minerals leasing system, information requirements are much more specific and extensive than under the mineral location system. The application for a prospecting permit filed with the Bureau of Land Management must indicate the mineral leasing law under which the application for a prospecting permit is made, as well as the specific mineral for which the prospecting permit is requested. It must also include a description of the land, of appropriate nature and in sufficient detail to accurately designate the location of the area for which the prospecting permit has been requested. This must include the total area of the land in acres and a description of the land in relation to the public land survey. Information concerning the applicant himself, including his citizenship and his acreage holdings for the mineral for which a prospecting permit application has been made, must also be provided. If the applicant is a corporation or an unincorporated association, the application must likewise contain pertinent information concerning the corporation's or association's status, its qualifications to hold a prospecting permit, and information concerning its stockholders and/or members, including their citizenship and mineral acreage holdings. If an application for a prospecting permit is made under the Mineral Leasing Act for Acquired Lands, rather than under the Mineral Leasing Act of 1920, the application for a prospecting permit must also contain the name of the federal agency from which consent to the issuance of the permit or lease must be obtained or the agency that may have the records covering ownership of the mineral interest involved in the particular portion of the public lands involved. Under a preference rights lease, the information obtained in the application for a prospecting permit also becomes a necessary part of the application for the lease. Similar information is required in any application for a competitive mineral lease under the present mineral leasing system.

Under the minerals disposal system, any bidder for or a purchaser of mineral materials from the public lands must provide information to the relevant federal agency indicating that he is either a citizen of the United States or a partnership or an unincorporated association composed wholly of citizens, or a corporation authorized to transact business in the state in which the mineral material is located. In effect, this is the only information that must be provided to the federal government, because under the minerals disposal system, the bulk of the resource information made available originates with the federal agency having jurisdiction over the particular mineral deposit involved. The government itself thus becomes the major source of public land information, rather than the private minerals producer. This is unlike the situations involved in either the minerals location system or the minerals leasing system in which the private minerals producer is the generator of most of the information about the specific public lands in question.

Under the Mineral Leasing Act, once a leasehold property is in production, there is a considerable volume of information that must be furnished by the minerals producer to the federal government through the regional mining supervisor of the United States Geological Survey. There is an explicit obligation to furnish plats, reports, maps, and other data provided in each particular minerals lease as well as in the regulations of the Geological Survey. Some of the requirements for information are contained only in the lease, while others are found only in the regulations, and others are in both the lease and regulations.

Specifically, the Geological Survey may require a plat showing development work and improvements on the lease lands, and this plat must be furnished at such times and in such form as may be prescribed by the Geological Survey. The minerals producer must also present information on stockholders, investment, depreciation, and costs, as well as a monthly report of production. Furthermore, he must provide maps and plans showing the proposed mining methods and plant lay-out, and these maps and plans must be submitted for approval before beginning actual mining operations. They must be modified if and as required by the regional mining supervisor of the Geological Survey. If subsequent operations require a radical departure from the approved maps and plans, supplementary maps and plans must be submitted to the Geological Survey for approval along with a statement of the reasons for the intended changes. In addition, maps of underground workings must be prepared in accordance with the federal government's requirements. These maps must be maintained regularly, and a copy must be furnished to the regional mining supervisor at least once every six months. Other maps showing surface boundaries, improvements, topography, and geological conditions must be prepared as the regional mining supervisor may consider necessary.

A minerals lease holder must also submit as promptly as possible to the regional mining supervisor seven copies of all core and other exploratory hole records. The core itself must be available for personal inspection by the regional mining supervisor, who is also entitled to cut the core and receive samples upon request. (See Twitty and Reeves, *op. cit.*, pp. 854-855.) The information requirements for mineral leases are far more extensive than the information requirements under any other mineral system operating in the United States today. Whether such a volume and frequency of information is actually required, or actually provided, in reality apparently varies from one region to another and from one property to another within any given region. Despite these requirements, there is still a severe lack of general knowledge regarding the mineral character of the public lands.

10. Reserve Mineral Rights Provisions

One of the prime realities of all of the public mineral land systems in operation in the United States today is that, in many cases, surface rights and mineral rights have been severed. As a result, it has been necessary to take this severance into account in many aspects of the existing systems. This is true not only where surface lands have passed from federal ownership with mineral rights withheld or reserved to the United States (i.e., retained in the public domain), or where surface rights have been reacquired by the federal government. Under the commodity disposal system, mineral materials on lands that have been patented (with respect to their surface rights), but where mineral rights have been reserved to the United States, may be disposed of under the Materials Disposal Act if such materials were subject to location under the mining laws prior to the Act of 1955 (which removed *common varieties* of sand, stone, gravel, pumice, pumicite, and cinders from location under the mining laws). Sand, gravel, and "ordinary" rock which have no value separate from the soil itself are not within the mineral reservation and therefore are not subject to disposal under the Commodity Disposal Act. They, in effect, form a part of the surface resources of the land.

A situation that has arisen because of the simultaneous existence of both the mineral location system and the mineral leasing system is that the owners of mine claims and mill sites patented (or validated) after the enactment of the Multiple Mineral Development Act of 1954 do not possess the rights to leaseable minerals if the land were known to contain leaseable minerals or were covered by a lease or prospecting permit. In other words, since 1954, those lands patented for locateable minerals have had the known leaseable mineral rights reserved to the United States. Thus, mineral patents issued after 1954 did not always vest the receiver of the patent with all mineral rights, but only rights to those minerals that were subject to the minerals location system. The rights to leaseable minerals have been reserved to the United States, and in mineral deposits where both leaseable and locatable minerals are intermingled or where removal of one necessitates the removal of the other, problems have arisen.

Since the early 1900's, a number of laws have been enacted providing for the sale of public lands but also providing for the reservation to the United States of mineral rights on those lands. These laws have, in effect, divided the public lands into two types, public surface lands and public mineral rights. Under some of these laws, the owner of the surface rights (if he has received them in fee simple from the federal government) is entitled to damages for any injury to his surface improvements or resources resulting from the exercise by others of the mineral rights that have been reserved to the federal government. Other laws, however, have made no provisions for compensating the surface owner for the adverse consequences resulting from the exercise of mineral rights by either the federal government or other parties. A number of other laws have also had the effect of rejoining the severed surface and mineral rights, either by withdrawing such reserved mineral land from any mineral location or entry or by conveying the severed mineral rights to the owner of the surface rights. (See Twitty and Reeves, *op. cit.*, p. 1090.)

C. STRENGTHS OF THE EXISTING PUBLIC LAND SYSTEMS

1. Variability

The multitude of statutes and court decisions that presently constitute the public land minerals system of the United States have at once imparted weakness as well as strength to the system. The early mineral laws of the 1800's recognized that there were real differences between certain types of mineral deposits (the initial distinction being between lode and placer deposits) and provided for different procedures in the development of each. Later legislation also recognized that there were real differences between hard minerals and petroleum, and the introduction of new legislation was designed to promote the effective development of both types of mineral resources without impeding the other. To a significant extent, the existing system has done just that.

There are certain other variations in the existing mineral lands systems that have facilitated the development of the mineral resources of the United States. Certain of the various laws that have been enacted regarding the disposition of minerals on the nation's public lands have distinguished between general public domain areas and areas for which there has been a specific use for the surface resources. Probably the greatest distinction made in this respect is that drawn between National Park and Monument areas, administered by the National Park Service, and the general public lands under the jurisdiction of the Bureau of Land Management. The placement of various types of land under the jurisdiction of diverse federal agencies has, in many respects, strengthened the public land system with regard to mineral resources. The strengths gained from these variations in the designated types of public land and in the variations in agencies given jurisdiction, however, have been relatively limited, compared to the weaknesses developed by such policies.

2. Land Costs

One of the strongest aspects of the present system of minerals utilization of the public lands of the United States has been along the monetary dimension. Under the minerals location system, a minimum non-productive cost is incurred by the actual or potential minerals producer in acquiring public lands from the federal government for minerals purposes. Actually, nothing is paid to the federal government for the in-place minerals on the public lands, but then minerals in-place rarely have a determinable value. (See Chapters 5 and 15.) As a result, the actual or potential minerals user is permitted to devote a maximum amount of financial resources to the acquisition of information about the physical state of the minerals on the public lands and in developing those minerals. Consequently, a maximum amount of money is spent productively on the land itself, rather than being diverted to the general fund of the United States. This has tended to result in a maximization of knowledge about and a greater development of minerals on the public lands under the minerals location system.

Under the minerals leasing system, although cash bonuses for competitive leases have tended to reduce the amount of money available for exploration and development activity on the land itself, other features of the monetary aspects of the leasing system have strengthened the nation's mineral resource position. The most notable of these is the sliding scale of rentals charged under mineral leases for phosphate, potassium, and sodium minerals. The minimum per-acre fee charged during the first year of the lease, with an increase during subsequent years to a maximum after a period of either three or five years (depending upon the commodity), has tended to encourage early development for production. This has undoubtedly strengthened the system and offset tendencies towards monopoly generated by other features of the system. The ability under mineral leases to offset rentals against royalties from production has also proved an advantageous feature of the system.

Under the commodity disposal system, the practice of allowing installment payments on mineral purchase contracts to be paid as the material is removed from the ground is a strong point for this part of the commodity disposal system. Also providing strength to the system is the flexibility inherent in providing latitude to local public land authorities in determining appropriate charges for certain mineral commodities existing on the public lands under their jurisdiction.

3. Other Strengths

There are a number of other features of existing mineral lands policy that have strengthened the system rather than weakened it. Under the minerals leasing system, the acreage allowances for prospecting permits and mineral leases are large enough to accommodate most minerals-producing activities for the minerals involved in that system. At the same time, the presence of such limitations has offset monopolistic tendencies promoted by other features of the system. Under the minerals location system, although the 20-acre-per-claim size limitation is woefully inadequate under modern conditions of technology and economic geology, the practice of allowing multiple claims has offset that inadequacy to a considerable degree. Under the minerals leasing system, the requirement that prospecting permit and lease areas be defined in terms of the public land survey has also been a definite advantage of the system.

The existence of the preference rights lease under the minerals leasing system for areas in which there is little known about the existence of leaseable minerals is a definite strong point of the minerals leasing portion of the total public land minerals system. Similarly, under the minerals location portion, the possibility that a *bona fide* minerals producer can obtain patent to the lands involved in the minerals-producing operation, as well as to certain lands (under the mill site provisions) needed for at least a limited portion of his auxilliary surface uses, is a strong point of that part of the public land minerals system. In recent years, the replacement of discovery pit requirements with drillhole requirements for discovery and assessment work has also strengthened the minerals location system.

Although the time periods generally allowed for discovery work on a mineral claim under the minerals location system are pitifully short, under the minerals leasing system, the time periods involved and their establishment in annual increments provide strength to that portion of the total mineral land system. Similarly, the longer time periods involved in the commodity disposal system are generally sufficient to provide adequate security of tenure (for at least small producers of such materials from the public lands) to be adequate.

In general, the established or initial working of the three portions of the public land mineral system, the minerals location system, the minerals leasing system, and the commodity disposal system, have provided (at least in the past) relatively free access to the public lands by potential users of the mineral resources on those lands. In the past, exploration for nonfuel minerals has been enhanced and encouraged by the statutes, and this has resulted in considerable development of the mineral resources in the West. The reservation of mineral rights under the stock raising and other patenting provisions has also assured that a maximum amount of public domain mineral resources would remain open to utilization by mineral users and not diverted to low-intensity agricultural uses for which relatively little value is returned from the land. In general, the minerals systems for the public land, since the 1860's, have been a success in permitting and encouraging mineral development on the public land of the 11 Western States. Whether they would have been a greater success under other provisions or under a completely different system is rather academic at this point. Whether they will continue to be successful, or if they will be even more successful in the future is, however, a very real and pertinent question.

D. WEAKNESSES IN EXISTING PUBLIC LAND SYSTEMS

1. The Multiplicity of Applicable Legislation

Any system of manmade laws is imperfect. The collection of existing laws in the United States that are applicable to the utilization of the nation's nonfuel mineral resources is an appropriate example of this imperfection. In fact, one of the major weaknesses in the existing public land minerals system is the fact that it is not really a system at all but a rather incoherent collection of sometimes inconsistent, sometimes conflicting, individual pieces of legislation, both national and state. Initially, of course, there were no public domain mineral statutes at all, but simply the common law which had developed from the custom and practice followed in the individual mining districts founded on the public lands. While there had been earlier laws dealing with minerals, the first significant recognition by the Congress of the United States of the need for legislation regarding mineral resources on the public lands came in the late 1860's and was followed within the next decade by several separate pieces of legislation. These laws in effect adopted the general practice that had been developed within the existing mining districts in the Western States and codified them into federal legislation. In other respects, however, the federal laws as finally enacted were vague and left considerable latitude to the individual states and the courts.

One of the major dimensions in which federal legislation has varied with respect to mineral resources on the public lands has been along commodity lines. One of the most severe weaknesses in the system as it exists today is the distinction between locateable and leaseable minerals. In the late 19th Century, there was a tendency to include all minerals under the location laws then in effect. With the beginning of industrial development in the West, however, around 1900 there grew a tendency to separate certain of the industrial minerals from the effects of the Mining Law of 1872 and to make these industrial minerals subject to other legislation. The primary impetus for such separation came from petroleum, but the need for industrial minerals was also an important factor. In effect, it removed these other minerals from the jurisdiction of the location laws and subjected them to federal leasing. The removal of specific commodities from the location laws at different intervals and under different pieces of legislation, however, quickly became rather haphazard and unrelated to either geologic or economic reality. (See Chapters 9 and 11.)

Today, the distinction between what is a *locateable* mineral (i.e., a mineral that may be treated under the Mining Law of 1872) and what is a *leaseable* mineral or a *disposable* mineral (to be treated under the Leasing Act of 1920 or the Minerals Disposal Act of 1955) is ill-defined and often subject to court definition. This has introduced considerable uncertainty and inconsistency into the legal system governing the utilization of mineral resources on the public lands. (See Chapter 14.)

Another weakness of the existing system is the distinction between lode and placer deposits. Originally designed for the late 1800's, when vein or lode deposits dominated the western minerals industry and placer deposits were still an important source of gold production in the United States, the distinction between lode and placer deposits was realistic. At that time, there were in effect no other major types of nonfuel minerals deposits. About 1900, however, the distinction became unrealistic with the growing importance of hard-rock deposits other than vein or lode deposits. With the decrease and virtual disappearance of significant placer deposits in the United States (except as sand and gravel deposits might be considered as placers), the lode and placer distinction has become simply a source of confusion. Most mineral deposits now mined commercially in the United States are neither lode nor placer.

In addition to the distinctions made in the existing laws between locateable and leaseable minerals, there are many specific commodity distinctions which make the legal system inconsistent, difficult to administer, and difficult under which to work. Probably the most notable of these is the oil shale distinction, wherein deposits of oil shale have been reserved from mineral entry because of their hydro-carbon content. Nevertheless, the same deposits contain other minerals, some of which fall under the leasing laws, some of which may or may not fall under the location laws, and some of which may fall under mineral disposal legislation.

Furthermore, there are specific commodity distinctions from one state to another. Sulfur, for example, is a locateable mineral in some states, while in other states it is a leaseable mineral regardless of the fact that sulfur is generally found within the same geologic environment wherever it is economically useable under existing technical and economical conditions. The specific definition of particular minerals in the legislations subsequent to the original mineral location law has invariably left gaps, because no list of minerals under the existing legislation is all-inclusive. Minerals in rocks are of such a nature that they do not fall into nice, neat legal categories. Most mineral deposits contain mixtures of minerals. In fact, many mineral deposits contain mixtures of both leaseable and locateable minerals, of minerals that have been subject to specific reservation and minerals that have not, and the utilization of any one cannot be done without disturbance or removal of the others. This natural mixture has also allowed unscrupulous minerals seekers to circumvent the provisions of the leasing laws by locating a claim for locateable minerals and drilling a leaseable deposit prior to bidding.

Weaknesses in the existing system of laws regarding nonfuel mineral resources on the public lands have also developed as a result of variation in specific legal provisions from one state to another. The basic mining legislation of 1872 left considerable latitude to the individual states in the establishment of detailed provisions for the basic mineral acquisition procedure. In effect, then, in the 11 Western States there are 11 different mining location laws applicable to the public lands. Minerals, however, do not change their characteristics in accord with state boundaries, nor do the technical and economic conditions of minerals utilization pay particular attention to politically drawn lines on the map of the United States, except for taxes. The result has been a distortion in what could otherwise be an optimum development of the mineral resources on the public lands.

With respect to geographic differences, on those federal lands that are open to location under the basic Mining Law of 1872, the provisions for locating claims, doing location work, recording and maintaining valid claims (i.e., doing assessment work) vary from state to state and are anything but uniform. For example, Arizona law requires monuments at four corners and at the center of the end lines of lode claims, resulting in six monuments per claim. New Mexico, however, requires additional monuments at the centers of the side lines of a lode claim, resulting in eight monuments for a rectangular claim. The latter state requires the filing of an affidavit of location work and a plat of the claims, whereas most other states do not. Both Arizona and New Mexico permit location work by drilling rather than by the simple excavation of so-called discovery pits, but in New Mexico a hole must be drilled on each claim. A number of other states do not recognize diamond drilling as a valid exploration tool. Furthermore, the federal statutes have left considerable latitude to the individual states in determining the requirements for the place and nature of both location and assessment work. The resulting specifications adopted by the different states vary widely.

The geographic variations that have created weaknesses in the existing mineral land system have not been restricted solely to variations between states. There has also developed a distinction between public land that was original public domain and public land that has since been acquired or reacquired. Different provisions of different laws treat these lands differently, although they might be geologically, economically, and in many cases even roughly geographically similar. This has caused problems in the utilization of mineral resources and has resulted in inherent weaknesses in the legal structure, particularly where both public domain and acquired public lands exist side by side or intermingled in a given mining district.

There is a third category of geographic distinction which has also caused considerable problems in the optimum development of the mineral resources of the West. This arises from the various legal provisions which distinguish public land falling within the National Forests from other public lands outside of the National Forests. In many parts of the Western United States, those areas which fall within National Forests are in the mountainous areas most favorable for mineral deposition and certainly (at least in the past) those areas most attractive for minerals exploration. Nevertheless, these areas, because they are in National Forests, are treated differently from other public land areas, many of which are situated at lower elevations and in less mountainous terrain with less exposed base rock geology.

Weaknesses have also developed in the existing public mineral land system as a result of variations in the monetary dimension. Under the basic Mining Law of 1872, the fees required of those who would develop the public lands for mineral purposes are now only nominal. The $5.00 per acre patenting fee can hardly be considered more than minimal, particularly when compared to the present cost of administering the public lands and the values involved in the surface use of most of the areas of the public domain. The fees required for the use of those minerals falling under the Minerals Leasing Act are considerably higher and in many cases are determined on a competitive basis. The differential between the two systems, as far as the monetary dimension is concerned, is considerable and, combined with other factors, has had a tendency to result in the misallocation of productive resources and investment capital.

There are further distinctions between those minerals removed from the public lands under the leasing laws and those sold under the minerals disposal legislation of 1955. In many respects the leasing laws require far higher payments than do the material sales. In many cases, the price paid for materials taken from certain public lands, particularly Forest Service lands, has not even been minimum in relation to the patenting fees, but has in fact been zero. Many commodities have simply been given away under free use permits granted by the United States Forest Service. In fact, where such minerals have been extracted under free use permits using roads constructed and maintained by the Forest Service, the revenue received by the federal government for these resources has in effect been negative. The result of these variations in the amounts of money received by the federal government has been broad inconsistencies in the value of mineral resources in place. This has resulted in a severe tendency towards the misallocation of investment capital and has also given a substantial incentive towards abuses of both the laws and administrative authority.

Accompanied by (and perhaps caused by) the multiplicity of applicable legislation to the development and use of nonfuel minerals on the public lands of the United States have been variations between the policies and conduct of the several agencies charged with responsibility for administering the public lands and their mineral resources. In general, the Bureau of Land Management of the Department of the Interior has had primary responsibility for such administration. Under certain legislation, however, and for certain areas, the United States Forest Service has in effect been given prime responsibility and authority. The Forest Service is under the Department of Agriculture, and a distinction in philosophies, policies, and conduct between these two departments has resulted in severe inconsistencies in the application of the public land laws with respect to nonfuel mineral resources. This has, in actuality, resulted in a different system of public land mineral laws, depending upon the particular agency with prime responsibility for administration. The same is true regarding the variations of responsibilities with regard to minerals on the public lands between the United States Geological Survey and the United States Bureau of Mines, both in the Department of the Interior. Furthermore, the division of responsibilities for certain functions on the public lands between the United States Geological Survey and the United States Bureau of Land Management has resulted in additional inconsistencies. These have had an adverse impact upon the optimum development of nonfuel mineral resources in the Western United States.

Under the numerous pieces of separate legislation that have been considered applicable to the nonfuel mineral resources on the public lands of the United States, there have been wide variations in the obligations of the government to the mineral resource user and to the holder of the surface rights. There have also been wide variations in the obligations of the users, particularly under the location laws as well as under the leasing laws. These variations have not necessarily been spelled out in the legislation, and perhaps that has been the biggest part of the problem. These provisions have become a part of the administrative law and thus change as the administrators change. Under some mineral leases, for example, extremely specific provisions are included regarding the treatment of disturbed land after mining operations have been completed. Under the mineral location laws, however, there are no such provisions. In fact, there is no opportunity to make such provisions because there is no lease, and ownership is transferred to the private developer of the mineral resources. Likewise there have been variations, some broad and some relatively minor, in the rights of the federal government regarding the performance it can expect from the developer and user of mineral resources on the public lands. There have also been variations in the rights of minerals users.

2. Inconsistencies Between Existing Law and Technical and Economic Reality

Probably the greatest of the weaknesses in the existing collection of legislation concerning the utilization or non-utilization of nonfuel mineral resources on the public lands of the United States is the unfortunate fact that the laws themselves, the court decisions regarding those laws, and the administrative regulations developed for the enforcement of those laws have in many instances lost all contact with technical and economic reality. One of the greatest fallacies in the existing law is the legislative use of the concept of a *valuable mineral deposit*. Under the law a *valuable mineral deposit* is apparently treated the same as a *deposit of a valuable mineral*. The two are not identical. In many respects they are not even similar. The fallacy dates, however, from the days when flakes of gold were immediately recognizable as valuable minerals, and a deposit which contained colors of gold, either in sand or gravel or in hard-rock quartz veins, was generally in areas that were already operating, i.e., in the established mining districts which had developed their own local legislation. Such deposits were thus recognizable immediately as *valuable mineral deposits* even though, strictly speaking, many of them were only *deposits of a valuable mineral*. It should be pointed out, however, that even in the 1850's and 1860's deposits of similar minerals (including gold, but more particularly of base metals) in areas inaccessible to adequate transportation were not valuable mineral deposits at all, because they could not be worked economically. As deposits of minerals other than gold came to be developed in the Western United States, the distinction between a *valuable mineral deposit* and the *deposit of a valuable mineral* became even greater and more significant. The legislation in existence today, however, in effect is still appropriate only for the conditions of 1849. Even the many court and administrative decisions that have been made since the passage of the initial legislation reflect a mentality concerned primarily with gold deposits in which the valuable mineral is visible and the limits of its deposition are well defined geologically. But with the advent of new gold mines of the Carlin type in Nevada, where the contained gold is invisible to the naked eye and can be determined only on the basis of chemical assay, even this remote contact of the law with existing physical reality has been removed.

A similar but even more wide ranging fallacy is the distinction in existing legislation between *mineral land* and *nonmineral land*. In geological reality, there is no such thing as nonmineral land. All land within the United States is composed of minerals. Whether or not these minerals are currently useable or susceptible to commercial extraction, processing, and use is another matter, but it does not follow that land where valuable mineral deposits are not known to exist is nonmineral. No land is nonmineral. By its very nature, it is composed of minerals.

Probably the best known example, and certainly the most obvious example of the foolishness of this misconception of nonmineral land is the first uranium boom of the 1950's. Uranium, prior to the development of nuclear energy, was not considered to be a particularly valuable mineral. Although it did have some limited uses, it was necessary for the element to occur in an extremely high-grade form to be of any practical value. As a result, before World War II, large areas of the Colorado Plateau region of Utah, Colorado, New Mexico, and Arizona were considered nonmineral in character, even though they were covered at the time by both minerals and rocks composed of minerals. The increase in the value of low-grade, uranium-bearing rocks turned these so-called nonmineral lands into mineral lands, virtually overnight. Of course, the rocks themselves had not changed in character but only in legal definition, a definition which bore no relationship to physical reality.

A second and more recent example can be found in the copper mining region of Southern Arizona, where a large area south of Tucson, covered by valley fill composed largely of unconsolidated and some consolidated sediments, was for many years considered nonmineral, primarily because the only rocks and minerals exposed on the surface were relatively common rock-forming minerals such as quartz, feldspar, and biotite. As a result, this land was classified nonmineral. Today it is the site of three major copper mines, two of which were developed without any surface indication of the presence of copper at all, and two larger copper mines are scheduled to begin production shortly. It is obvious, then, that the previous nonmineral classification of the land was erroneous. The error was made not because the land was known to contain low-grade copper minerals that were simply not economically removable or producible at the time of classification, but because it was thought that there were no metallic minerals there at all. The classification considered only the surface and not the subsurface conditions. Because the existing laws make such distinctions between mineral and so-called "nonmineral" land, serious problems have been created in the optimum utilization of the nonfuel mineral resources of the public lands.

Closely related to the fallacious concept of nonmineral land is the concept of *common varieties* that has come into widespread use since the minerals disposal legislation of the mid-1950's. This concept is also erroneous because, in effect, there is no such thing as a truly common variety of a rock or mineral. Every mineral deposit is distinct from others either geologically, economically, or in engineering terms. Even though two deposits, say of calcium carbonate rock, may be identical in chemical composition, they may not be located in the same place. Therefore, their *economic* characteristics could be distinctly different. On the other hand, there may be two deposits of sand and gravel, for example, both located within a given radius of a using site and therefore economically (as far as transportation costs are concerned) identical. But they might be *geologically* different. The amount of clay or decomposed granite in one of the sand and gravel deposits may be higher than in the other, thereby inhibiting its use in specific construction purposes. The fallacious concept that all rocks are the same that has resulted in the term *common variety* has caused considerable difficulty in the optimum use of industrial mineral resources, and it is one of the major weaknesses of the existing legal system.

Perhaps not quite as serious as the erroneous classifications of land as *nonmineral* and of rocks as *common varieties* is the tendency to classify minerals as either *metallic* or *nonmetallic*. Nevertheless, this distinction has also caused problems in optimum natural resource utilization (including both land and minerals) and in the optimum allocation of available capital. As has been pointed out in Chapter 2, a number of mineral commodities are both metallic and nonmetallic in their uses. As the term *nonmetallic minerals* is currently used, it is synonymous with *industrial minerals* and includes those mineral commodities used primarily for their physical or chemical characteristics as compounds rather than as sources of a metal or other element. Bauxite, although mined only in limited quantities domestically at the present time, is both a refractory and an abrasive and therefore an *industrial* or *nonmetallic* mineral. It is also the principal source of aluminum, and thus can also be considered as a *metallic* mineral. Sodium chloride, i.e., rock salt, is both an *industrial mineral* (thus, a *nonmetallic*) and a source of metallic sodium. Therefore, rock salt could be considered a *metallic* mineral, although generally it is not so considered in current practice. The distinction, then, between metallic and nonmetallic minerals are not consistent with either geologic or economic reality, and the arbitrary distinction has caused problems in the proper allocation of capital and labor in the development of mineral resources. The most notorious example of the problems so caused involves the oil shale regions of Colorado and Utah, where minerals normally thought of as nonmetallics are being treated as metallics and vice versa. The most severe example, of course, is presented by uranium minerals, which once were considered *nonmetallics* but which have since become a source of the *metal*, uranium, which is essentially a *fuel*.

All of these inconsistencies between the law and reality, including the fallacious concept of *common varieties*, the confusion between the *valuable mineral deposit* and the *deposit of a valuable mineral*, the erroneous concept of *nonmineral land*, and the arbitrary distinction between metallics and nonmetallics (and even between fuels and nonfuels) have resulted in substantial weaknesses in the existing legal system with regard to nonfuel minerals on the public lands. Any discrepancy between the law and geologic, engineering, and economic reality is likely to create a severe weakness in the legal system.

3. Inconsistencies Between the Law and the Realities of Mineral Exploration

There are also a number of inconsistencies that have developed in the search for nonfuel mineral resources under the existing legal system. The position of current public land law and policy regarding many phases of the search for mineral resources has created both physical and economic problems, and is likely to create more as judged in the light of present conditions and trends in nonfuel minerals exploration. This has been particularly true of those provisions establishing discovery and assessment work requirements on mineral claims coming under the jurisdiction of the Mining Law of 1872 and the various state statutes related to it. At the present time, federal mining laws state that the first requirement for locating a lode claim (itself an inconsistency) is to make a mineral discovery. This discovery consists of finding a vein or a lode containing a valuable mineral in place either upon or underneath the surface. According to the law, it must be an actual discovery and not simply an indication of the presence of valuable minerals at depth. According to law, however, it is not required that the quantity of mineral exposed be of sufficient size or grade to be mined at a profit, but it is required that evidence be presented to justify a person of ordinary prudence in making an expenditure of both labor and money on the deposit with a reasonable prospect of success in developing a valuable mine. Court decisions have treated this stipulation in various forms. It is not really quite clear whether the currently used version of the law is or is not at variance with economic reality. It appears that the most recent judicial decision (i.e., that of the Coleman Case) and the so-called *concept of marketability* (in reality the *concept of profitability*) have altered this. The fact that such discovery requirements are even necessary at the exploration stage of mineral deposit utilization, however, makes them inconsistent with economic and technical reality. In many instances, the profitability of any attempt to remove a mineral commodity from the earth and sell it can only be determined after actual production has taken place for some time.

Probably the greatest problem in relation to exploration is the provision that a valid discovery must be of mineral in-place. When the original mining location law was passed, nearly all hard-rock ore deposits were in the form of veins, and they were usually exposed at the surface. Such conditions no longer exist. In fact, under present technical and economic conditions, it may be many years before the actual discovery of sufficient mineral in-place may be made on a piece of land with a high mineral deposit potential. During this *prediscovery time*, however, there is absolutely no legal protection for the person who is searching for minerals and has found strong indications of their presence. This *lack of prediscovery protection* is one of the major weaknesses in the existing public land system, regardless of whether the minerals sought fall under the leasing laws, the Minerals Disposal Law, or the Mining Law of 1872.

One of the most obvious weaknesses of the minerals location system as it is operated in the United States today is the relatively small size limitation on any one mining claim, be it lode or placer. With the virtual disappearance of placer mining operations in the United States, however, limitation on the size of lode claims is of greatest relevance. Since World War II, only the smallest high-grade uranium deposits have acquired space of less than one mining claim for an effective mineral property. In virtually every other circumstance, the need for the staking of multiple claims has been extensive and obvious. In relation to the size of mineral deposits currently being mined in the United States and the size of deposits that can be expected to be mined within the next two decades, the specification of the maximum extent of a lode claim at 1,500 feet by 600 feet (approximately 20 acres) is absurd. It has resulted in needless surveying to mark each of the separate claims needed to define an area of sufficient size on which to operate a commercial mineral property. In addition, other requirements of the law established on a per claim basis have made other work that would otherwise be needless, necessary simply to satisfy statutory requirements.

While the 20 acre maximum size of a mining claim is absurd enough with respect to mineral production operations, it is even more ridiculous in the light of mineral exploration needs. Today, minerals exploration is carried on over relatively large areas by motorized equipment as well as by air. The present size of claim, as specified in the Mining Act of 1872, bears absolutely no realistic relationship to the current facts of minerals exploration. This has resulted in additional costs and substantial inconveniences in the search for nonfuel minerals on the public lands of the United States.

Under the minerals leasing system, there are also weaknesses resulting from the acreage limitation provisions of the system. Of these provisions, the one that is most in conflict with reality is the per state limitation on the lease holdings of an individual or corporation for a given mineral. Mineral deposits do not normally recognize state boundaries. This is particularly true in the phosphate field of Idaho, Utah, Montana, and Wyoming, where many deposits are located near or on state borders. It is also true that the way in which the acreage limitations are established makes them effectively apply only to completely honest organizations or individuals or to such individuals or organizations who are afraid of being too obviously dishonest. There exist, at present, numerous means for circumventing the statutory limitations on acreages held by any one individual. Furthermore, because of the acreage limitations on lease holders and prospecting permits, there is a tendency to attempt to control up to the maximum area allowed. The acreage limitation, therefore, becomes not a maximum amount contained in any one lease or prospecting permit, but a defined amount. (See tables in Chapters 7 and 8.) This leads to the inclusion within a given lease of areas not really necessary for minerals utilization. It also restricts certain operations in size and therefore in the amount of planning possible for the utilization of a given mineral deposit that may extend beyond the legal maximum area.

The required payments for claims, leases, or prospecting permits have, in many cases, proven to be a severe weakness of the public land minerals systems as they have been formulated since the late 1800's. Under the minerals location system, the $5 per acre patenting fee for a lode claim is now probably too low. At the time of its establishment, it was equivalent to a little more than a day's wage for a skilled miner and was greater than the cost of raw land for other purposes. The patenting fee has remained constant over the last 100 or so years, but the cost of other items has risen. As a result, the relative significance of the $5 patenting fee has decreased and has led to abuses and attempted abuses of the mining law in order to gain relatively cheap federal land for nonmineral purposes. For those *bona fide* mineral seekers and producers, however, the $5 per acre fee has been a benefit, allowing them to put more money into actual exploration and development activities. Nevertheless, the decreasing significance of this fee has probably been a greater overall weakness than a strength in the minerals location system.

The lack of any necessary payment at all in the acquisition of mineral lands by the location of unpatented mining claims (i.e., any payment to government other than a minimal county court house filing fee) has led to similar abuses by those attempting to use the mining laws for real estate acquisition or for the extortion of money from *bona fide* minerals producers or surface landowners. Making these minimal filing fees even less significant is the fact that the price of most raw, undeveloped acreage in the West has gone considerably above $5 per acre. In many public land areas near urban centers, particularly in the Southwest and along the Pacific Coast, this $5 fee in relation to current prices for raw acreage is an open invitation to abuse of the mining laws. The $2.50 per acre patenting fee for placer claims is, of course, an even stronger invitation.

One of the most severe weaknesses of the minerals leasing system that has developed is the requirement for cash bonuses under the competitive bidding arrangements for mineral leases. In many cases, prohibitively large bonuses have hampered the work of medium-sized or smaller minerals producers. The result has been that in the United States today there are virtually no small producers and really no medium-sized producers of phosphates, potash, sulfur, or sodium minerals. *This has been a direct result of the high capital requirements of speculative land acquisition, not the technical requirements of minerals production.* The competitive bonus bid requirement has made a definite contribution towards the establishment of oligopoly in these mineral producing industries. Furthermore, the existence of cash bonuses tends to promote rapid mine development and high-grading, a practice that leads to the waste of mineral resources. Because a high cash bonus must be returned rapidly to the investor from product sales, there is a strong tendency to get as much value out of the ground as fast as possible in such situations. This has an adverse effect upon the overall efficient development of a given mineral deposit. This leads to generally poor conservation practice.

One particular weakness of the competitive bonus system is that the bonus bid must frequently be made by the potential producer on the basis of incomplete information. The would-be minerals producer, in effect, is buying a pig in a poke. A similar situation exists even under preference rights leases where the securer of a prospecting permit does not know the payments that will be required under the later preference rights lease at the time at which the prospecting permit is secured. The minimal cost of the prospecting permits themselves has, as in unpatented mining claims, resulted in the manipulation of permits for speculative rather than *bona fide* exploration purposes.

One of the most serious inconsistencies between existing public land mineral law and geologic, technical, and economic reality is the concept of *mineral discovery* and the requirements in the laws for a specified amount of *discovery work*. Under present mining laws, the first requirement for locating a lode claim is to make a mineral *discovery*. This consists of finding a lode or vein containing valuable minerals in place either upon or underneath the surface. It must be an actual discovery of such minerals, not mere indications of the presence of mineral at depth, and must be sufficient to justify a person of ordinary prudence in making an expenditure of both labor and money upon the claim with a reasonable possibility of developing it into a valuable mine. Although initially it was not necessary for the discovery of a valuable mineral to be in sufficient quantities to make commercial utilization obviously feasible, more recent rulings seem to indicate that such is the current status of the law. The thought that during the exploration phase of minerals utilization a mineral deposit can be found that is *obviously* useable on a commercial scale is patently ridiculous. Mineral deposit discovery is no longer (if in fact it ever was) a single event. It is a process, a series of events, that often must take place over many years. The legal concept of *discovery* itself then is inconsistent with the realities of both geology and present minerals exploration. What present-day mineral seekers do discover is usually some type of anomaly. Whether or not this anomaly later proves to be a workable orebody can only be determined by adequate time and additional examination and evaluation. In fact, whether or not a given mineral deposit is an orebody is really only proven after it has been completely worked and the profit and loss statement for the operation calculated.

Because mineral deposit *discovery* is necessary in order to secure any tenure rights under the existing minerals location system, its requirement makes the entire system inconsistent with current reality. The statutes actually assure no rights to the discoverer of a geological, geophysical, or geochemical anomaly. Although the doctrine of *pedis possessio* has, to a certain extent, eliminated this weakness in the existing system, events in recent years in Utah and elsewhere have indicated that this is far from an ironclad guarantee. Furthermore, *pedis possessio* has offered no protection against agencies of the federal government.

Coupled with this discovery requirement inconsistency in the minerals location system are the extremely short periods allowed by the various state laws for the validation of a mining claim on the public lands. The range of from 15 days to 120 days for the completion of discovery work is completely unrealistic. Some properties have required 10 years or more for a competent deposit examination and evaluation before it could be known whether a discovered anomaly was in fact a discovered mineral deposit of commercial characteristics. Under current examination and evaluation practice, any time period for validation of less than one year is inconsistent with geologic and economic reality.

Coupled with the statutory requirements in the 11Western States regarding time limits on claim validation work are the specifications for the nature of the work itself. The antiquated requirement of the discovery pit of so many feet deep by so many feet long or wide, containing a given volume, is completely unrealistic in this day of deep-seated deposits, geophysical and geochemical exploration methods, and deep-hole diamond core drilling. A few states have made the core drill an acceptable means of discovery work, but the majority still require surface excavations that are completely unrelated to any actual exploration or mine development work. These discovery requirements, as well as the small size of claim and the requirements that discovery work be done on each claim, have resulted in excessive expense and effort by both minerals producers and minerals seekers, as well as excessive scarring of the land in potential and actual mineralized areas.

Claim location and validation costs on large blocks of claims (i.e., blocks containing from 100 to 300 claims) that are commonly staked to cover large low-grade targets range in the Southwest from $100 to $200 per claim. Variations in the costs of claim location and validation depend primarily on the accessibility and roughness of the terrain. These costs do not include the cost of formal surveying necessary for mineral patenting. Formal surveying may add from $25 to $100 to the cost of each claim. The per claim cost of staking and doing location work is usually considerably higher for small claim groups than it is for large claim groups.

On one property in Arizona in moderately rough terrain, but with moderately light brush cover, the placement of discovery monuments and the recording of all of the claims for a 250 claim group took a four-man crew 10 days and cost approximately $3,500. The subsequent monumenting of claim corners and endlines with a two-man crew required 30 days and cost approximately $2,500. The validation or discovery work, which was done in this case by core drilling using two diamond drills and involving 25 relatively shallow holes, took 65 days and cost $30,000. This was spent for drilling supplies, drill site preparation, and roads. Thus, the total cost of locating and validating (i.e., performing the discovery work required by statute) these 250 claims was $36,000 and required 105 days. The cost per claim was $144. The discovery work did not yield information sufficient to determine the existence of a workable orebody, but was really only sufficient to meet statutory requirements within the legal time period. Thus, although the argument is advanced vociferously by many (private individuals as well as government officials) that mineral claimants get large tracts of land free or for nominal sums, this is not necessarily true if the person who acquires the land under the minerals location system is a *bona fide* minerals producer. In addition to the cost of staking and recording a claim, at least $100 per claim must be expended for discovery work. The statutory per claim discovery work requirement has resulted in additional costs per mineral deposit compared to the costs necessary in the 1800's when such legislation was initially adopted. For example, for a mine in the 1800's occupying two claims, at a $100 per claim the total discovery work amounted to $200. At mid-20th century, however, with a moderate size mine covering 100 claims, at $100 each the location work would be $10,000. And it should be remembered that this is a relatively fruitless expenditure, yielding virtually no useable information.

The costs incurred in patenting claims are also considerably more than the nominal sums paid to the federal government. Official surveys must be made and paid for, the mineral potential of the ground must be explored and proven, and the necessary legal work requires the usually expensive services of a lawyer. As a result, per claim patent costs often run into thousands of dollars. The cost of a patented claim to the *bona fide* minerals producer is not particularly cheap.

The unpatented mining claim is another situation, and the cost of a patented claim to the land speculator is also something else again. The 120 days' maximum allowed for claim validation and discovery work would normally not be sufficient to prepare a claim for patenting. Adequate testing for such purposes would require at least several years under present patent requirements.

There are also inconsistencies in the environmental control provisions contained in most prospecting permits under the mineral leasing system. Existing exploration methods in reality (except for the scarring of the land made necessary by statutory requirements for discovery pits) require relatively little in the way of disturbance to the physical surface environment. The only major exception to this is the need for roads where the placement of drills is necessary in order to properly examine a given target area and to evaluate a mineral deposit. Part of the need for roads is promoted by existing statutory requirements for discovery work, which tend to promote the physical movement of materials rather than the acquisition of knowledge about the mineral resources in a particular area. For example, a realistic and technically appropriate expenditure of funds on the development or exploration of a mineral claim or group of claims would be the preparation of an adequate topographic map. Such preparation would require virtually no disturbance of the surface environment. Nevertheless, such work is not as acceptable as the construction of a road on the property in question, even though they might require the same amount of money.

Throughout the existing mineral land system, including both the minerals location system and the minerals leasing system, the emphasis has been on the physical movement of material as evidence of intent or good faith in the exploration and development of the public lands for mineral purposes, rather than on the acquisition of knowledge about those lands. This misplaced emphasis has been the primary cause of damage to the surface environment resulting from minerals exploration. Under existing technical conditions, the conduct of most minerals exploration can be made without serious or permanent damage to the surface environment, even for those with the strictest aesthetic criteria. Nevertheless, under prospecting permit provisions, severe and unrealistic restrictions are often placed upon the minerals seeker and the conduct of his search. On Forest Service lands, such restrictions tend to be even more strict than elsewhere in the public domain. These restrictions are not always consistent with geologic, technical, or economic reality, but only with an agency attitude that sees mineral resources as the least useful of all natural resources (some agencies not even acknowledging that minerals are natural resources), coupled with the attitude that minerals utilization is the worst possible use of the public lands.

Certainly, environmental control provisions as they exist today with respect to *regional reconnaissance* are completely unrealistic. An excellent example of this has been provided in the Organ Pipe Cactus National Monument in Southern Arizona where minerals exploration has been permitted and conducted for years by both large and small minerals seekers. In certain instances, the supervisory staff of the National Monument were not even aware that minerals exploration was being done until they actually saw exploration personnel at work, because *there had been no visible disturbance of the surface environment*, not even tire tracks caused by off-road exploration vehicles. In the normal conduct of most regional minerals reconnaissance, there is likewise a minimal effect on the surface environment. In the normal conduct of *target area examination* and *deposit evaluation*, there is usually a somewhat greater impact caused by the need for access roads and the preparation of drill sites. The adverse effects of these can also be kept to a minimum, however. Under many statutory requirements for discovery work, the disturbance of the surface environment during exploration has been aggravated because of provisions requiring discovery pits or deliberate excavation from the surface, whether or not such excavation is needed. In most cases, it has not been needed. Nevertheless, extremely specific and unrealistic environmental control requirements for exploration work under prospecting permits have often hampered the efficient conduct of that exploration work.

4. Inconsistencies Between the Law and the Realities of Mineral Development

Under the minerals location system, one of the most serious inconsistencies between the existing law and the physical realities of minerals development involves the availability of land for non-mining purposes. Virtually every mineral deposit that has been developed within the past 20 years has required some type of surface facility for beneficiation. The five-acre millsite provision, however, in virtually all cases has been woefully inadequate in providing sufficient land for necessary surface facilities. Furthermore, the acquisition of so-called nonmineral land for supposedly nonmineral purposes (such as beneficiation or advanced processing and attendant waste storage) has in many cases been extremely difficult, requiring complicated land exchanges or purchases of land for unusually high prices and in adverse situations. Thus, despite the fact that land under the minerals location system has been generally open for the development of mines, the availability of land for the necessary adjunct facilities and activities has been inadequate. Under current technological conditions, this is a serious weakness of the existing system.

The most severe weakness in the minerals location system regarding minerals development, however, is found in the statutory tenure requirements, including those involved in claim patenting procedures. As has been previously mentioned, a critical weak point in the system has derived from the so-called *marketability* (in reality, the *profitability*) *doctrine* of the Department of the Interior and the courts. The criteria now demanded for successful application for a minerals patent appear to specify that an entire working mine must be developed and in operation before tenure can be assured for the minerals land involved. The *marketability* (or *profitability*) *doctrine* is not consistent with economic or technical reality. The profitability of any given business enterprise, be it in the minerals industry or any other area of private economic activity, cannot be definitely indicated before operation. And in many cases it cannot be proven until after operations have ceased.

Furthermore, for many mineral commodities (principally among the industrial minerals), there is no established market before minerals production takes place, nor can there be. In many instances, a market must be developed along with the mine, or along with production from the mine, as a reliable source of supply comes into existence and the producer is able to establish his reliability and the quality of his product. The *marketability* (or *profitability*) *concept* currently in use for determining the validity of mineral claims is, therefore, in strong disagreement with existing technical and economic reality. Its utilization in decisions involving the development of mineral resources on the public lands has created a severe weakness in the entire public land system for minerals.

There are, of course, other inconsistencies between existing mineral law and the realities of mineral resource development. Most of these, although at times serious, are generally of less significance than the weaknesses created by the marketability doctrine and other criteria for determining the validity of mineral claims. One of the more serious of these less serious inconsistencies is the variation in the law providing for the alleviation of conflicts between mineral producers or developers and the holders of surface rights. In some instances, surface rights holders must be compensated for damages caused by mineral development, while in other instances they need not be. This variation in the status of the surface lands can cause considerable difficulty in the conduct of mineral deposit development, largely through ignorance of which situation (requiring or not requiring compensation) exists, rather than through the need for the compensation of surface rights holders.

Another concept of the existing law that is inconsistent with current reality and that has caused problems in mineral resource development has been the *principle of extralateral rights*. While in recent years, litigation arising from the application of extralateral rights has been relatively slight compared to the extensive litigation that occurred in the late 1800's and early 1900's, the principle has a potential for causing far greater trouble than it has. The *principle of extralateral rights,* under which a mining claim owner may exercise mineral rights beyond the vertical plane that may be projected from the surface boundaries of his claim, is no longer consistent with the types of mineral deposits being developed. Apparently because of this, litigation arising from the principle has decreased. Nevertheless, in the future, new minerals may come into prominence that occur in geologic structures that are neither massive nor flat-lying in character. The principle, although it bears no relationship to *engineering* reality, could cause problems, however, because of the facts of *geologic* reality.

A weakness of all three of the existing public mineral land systems is the lack of available information regarding the mineral resources of the public lands. The fact that many areas of the Western United States still have not been incorporated within the public land survey system has been a hindrance in effective mineral development. The lack of reliable published information regarding even the topography, and in particular, the general surface geology of many areas of the public domain has also hampered mineral resource development. Coupled with this lack of information is what may perhaps be too much information in the form of estimates of so-called mineral reserves using various concepts of reserves, none of which at present are consistent with geologic, technical, or economic reality. These estimates tend to provide a distorted picture of the nation's mineral resources and have a resulting tendency to misdirect efforts and finances devoted to mineral resource development. This weakness, of course, is not really part of the public land mineral system as such, but rather is part of the nation's total mineral resource policy in general. Nevertheless, the use of certain unrealistic concepts of mineral reserves in conjunction with the public lands, and particularly in both the minerals location and the minerals leasing systems (with respect to procedures for mineral development and decisions regarding tenure status), results in significant weaknesses in both systems.

5. Other Inconsistencies

Under the minerals location system, the inconsistencies between the public land laws and the economic, technical, and geologic realities of mineral resource utilization have relatively little effect upon the production phase of mineral resource utilization, because most production of locatable minerals is from lands which have passed from the public domain through the patenting procedure. As a result, most of these lands are now in private hands. Problems do arise on such lands, however, when there is a need for significant expansion in mineral production with the resultant need for the development of adjoining areas that had not been acquired in the earlier patenting of the public lands. On such occasions, the inconsistencies that arise in exploration and development similarly influence the production phase and are likewise detrimental to the optimum utilization of mineral resources.

Where minerals production is from unpatented mining claims (and particularly in National Forest areas), the inconsistencies between the law and the geologic, technical, and economic realities of minerals production form a persistent weakness in the entire minerals land system. Probably the greatest inconsistency (particularly in the National Forests) lies in the imposition of environmental control requirements that are not consistent with *optimum* (not *maximum*) mineral resource utilization and which proceed from an apparent bias against mineral resource use that favors the preservation of vegetation as a natural resource.

The greatest inconsistencies between the law and the realities of mineral production exist in the mineral leasing and commodity disposal systems. Under the mineral leasing system, the intensive and extensive supervision over mine production operations by the regional mining supervisor of the United States Geological Survey represents a severe weakness of the leasing system. The entire concept of this supervision is methods-oriented rather than objectives-oriented and, in effect, pits the opinion of the technical staff of the minerals producer against the opinion of the technical staff of the Geological Survey. In many aspects of minerals production, technical opinion is quite variable, and it has consistently varied between minerals producers and the federal agencies responsible for administering public land mineral policy

Throughout the minerals leasing and commodity disposal systems, perhaps the most serious weakness regarding the production phase has arisen as a result of inconsistency between the law and economic reality. This inconsistency is the policy that calls for the maximization of *current* federal revenues. The whole concept and practice of competitive bidding is designed to maximize federal revenue in the current fiscal year. This extremely shortsighted policy has resulted in poor conservation practices and a far less than optimum utilization of the nation's mineral resources. Maximization of immediate federal revenue does not permit proper long-range planning and does not allow maximizing revenue over a longer-run period. The use of bonus bids, high royalty payments, and competitive bidding on a strictly per unit price basis in commodity disposal are reflections of this shortsighted federal revenue maximization concept. It forms a serious weakness of the entire natural resource policy of the nation as well as of the public land minerals system.

Despite the fact that most of the weaknesses in the nation's public land minerals systems are in the exploration and development stages (with some carry-over into the actual production stage), there is also one severe weakness found regarding the post-production phase of mineral resource utilization. This involves the concept of land *reclamation* after mining. The concept, as currently advocated under the leasing laws and commodity disposal programs, requires that mined-out land be *returned* to the condition in which it was found prior to mining. In many areas of the West, the condition in which land was found prior to mining was pretty poor. The concept fails entirely to recognize that in many instances disturbance of the surface for mining purposes can lead to an improved use of the land. By insisting that land that has been disturbed by mining operations be returned to the state in which it was found prior to mining operations, the regulations and stipulations of the law do not recognize that land use can be improved by disturbance. This lack of recognition comes despite the fact that both miners and farmers have been familiar with this reality for centuries.

Accompanying this conceptual weakness that demands reclamation, or the return of disturbed land to its prior state, is the loss of post-production tenure benefits to mineral users of the land under the minerals leasing system. Under the mining location system, it is possible for the owners of patented lands to have an incentive (through private gain) in the improvement of the use of land on patented claims once mining activity has ceased. Under the mineral leasing system, however, there is no positive incentive for the minerals producer to improve the use of his land after the cessation of mining activities. As a result, the government has found it necessary to resort to penalties and contract provisions imposing specific land reclamation procedures. In many instances, these provisions have gone to ridiculous detail in specifying the nature and extent of post-production activity on mineral lease land. But where there is no positive incentive for improving the status of the land, penalties and enforced requirements often tend to become rigid and over-detailed. This lack of incentive under the mineral leasing and mineral disposal systems for the improvement of land that has been disturbed by mining operations after mining operations have ceased is probably one of the most serious inconsistencies between the law and economic and technical reality. It is undoubtedly one of the most serious weaknesses of those two mineral land systems and one that is likely to become more critical in the years to come. The same weakness is also found under the mineral location system in those areas where the surface is controlled by the United States Forest Service.

6. Administrative Weaknesses

The attitudes apparently held by many of the administrative agencies and personnel responsible for administering and enforcing the public land laws of the United States with regard to mineral resources have, over the last two decades, formed a serious weakness in the entire public mineral land system. In conjunction with these attitudes, the administrative procedures that have been set up with respect to minerals utilization on the public lands have tended to perpetuate these weaknesses and the associated disadvantages of the system as a whole. One of the most serious weaknesses in the existing system in this respect involves the restriction of disputes between private individuals and the government to arbitration and final decision by Department of Interior personnel within the Department of the Interior. This does not allow for an impartial hearing and the equitable adjudication of such disputes. It can be claimed that there are legal provisions for taking disputes out of the Department of the Interior to the courts. For all practical purposes, however, it is possible for the Department to continually recycle disputes within its own structure by simply remanding disputes down the line for hearings or review at lower levels. Furthermore, the delaying tactics that can be used are strongly adverse to the small miner and prospector. As a result, the small miner or prospector has no effective legal recourse against the Department of the Interior. The same is true with respect to the Forest Service.

The structure of Interior Department hearings and judgment procedures is such that decisions have frequently taken a very long period of time. In some cases, appeals involving six to 10 years have elapsed before a final decision has been reached. Except for a few major companies, the private contestant normally has neither the time nor the financial resources to endure such lengthy proceedings. Furthermore, cases which, on appeal, may be remanded often have been remanded to the same hearing examiner who conducted the initial hearing, even after the appeal had reached the Secretary of the Interior.

Publication of notices of hearings and of changes and proposed changes to be made by the Department of the Interior in its administrative regulations is wholly inadequate. Such publication is largely limited to notices in the Federal Register and to small legal notices in unobtrusive portions of local newspapers. The form of the publication notice does not always indicate sufficiently the intent or the importance of proposed changes to even the various segments of the public who do read those notices. Information pertaining to land areas is given by legal description, which in many cases does not make the location and extent of the area in question readily apparent to the reader. Frequently, notices (when they are mailed) are mailed at such late dates that effective action before deadlines is virtually impossible. Furthermore, notices of action by the Department of the Interior against private parties are not always clearly worded as to their importance to these individuals, nor are these notices served with sufficient time for the private party to initiate effective counteraction. In fact, in many cases, no *effective* notice is given at all in actions where a contest could be adverse to the Department.

The attitude that has been promoted and fostered by the Department of the Interior that the staking of claims for mining purposes is simply a way for the general public or unprincipled real estate promoters to get public land free of charge is misleading and erroneous. Quite the contrary, considerable expenditure is incurred by the *bona fide* mining claimant to stake ground, do location work, assessment work, make a mineral discovery, and if he feels he has a chance, patent (or at least attempt to patent) those claims. Such expenditures are required by both law and reality.

The Department of the Interior has administratively withdrawn large areas of land for wilderness, primitive, and similar classifications, and has frequently so classified these lands without sufficient notice and without sufficient proof of their *nonmineral* character. In many cases, such lands have been classified as *nonmineral* despite strong evidence of their mineral character, which in some cases has included operating mines. Examples of this are legion. In so doing, the Department of the Interior has removed and destroyed, for all practical purposes, a significant segment of the nation's mineral resources. The ability of the Department to do this represents a serious weakness of the existing public land system. Present law allows the Department of the Interior to withdraw and reclassify land and issue mining regulations virtually at will and without notice to the public of the various implications and ramifications of such actions, whether they be national or local. This permissiveness granted to the Department of the Interior presents a serious weakness of the entire public land mineral system, particularly when the attitude of the Department is adverse to mineral resource development. *It could be likewise, of course, a weakness for the effective utilization of any other natural resource,* if the personal attitudes of Department of the Interior personnel were so inclined.

The Department of the Interior has preferentially and without any apparent just cause in many instances taken action against segments of the mining industry, and in particular against small miners and prospectors who lack the means to fight such action. On the other hand, promoters and land speculators who have staked claims for obvious nonmineral purposes are rarely prosecuted and even then only under pressure from conflicting private interests. The easy patenting of spurious gold placer deposits in Central Arizona in the early 1960's is a classic example of just such action.

7. Summary

The weaknesses of the existing public land minerals systems are many. A number of them arise from the multitude of legislation applicable to the mineral resources of the public lands and from the wide variations in the treatment of mineral problems and issues on the public lands through various pieces of legislation and the regulations of various agencies.

There are many other weaknesses in the existing system caused by severe inconsistencies between the law and geologic, technical, and economic reality. Many of these weaknesses are found within the minerals location system. These largely result from the fact that the system was developed initially in the 1860's and 1870's as appropriate to the mining of gold, silver, and mercury from placer and relatively small vein deposits in the western mountains and valleys. Basically, the law has not been adapted to meet changing conditions in the nonfuel minerals industry. In fact, virtually the only adaptation that has been made as a concession to modern technology has been the recent change in requirement by several states that diamond drill cores may be substituted for the previously required discovery pits. Diamond drills were in widespread use in minerals exploration before World War I. (See Chapter 7.)

In the minerals leasing system, the primary weaknesses are the result of inconsistencies between the law and economic reality, with perhaps the most serious of these resulting from the erroneous concepts involving the maximization of current federal revenue and land reclamation. In the commodity disposal system, the most serious weakness in the system is the fact that it employs the concept of *common varieties*. This last concept and several others in use throughout the entire mineral land system (including *discovery, nonmineral land,* and the distinctions between *metallic* and *nonmetallic* minerals) are seriously inconsistent with geologic and physical reality. As such, they form a serious weakness in the entire public land system for minerals.

Other major system weaknesses have arisen from the administrative procedures and policies followed by the Department of the Interior and the Department of Agriculture. In many respects, these weaknesses appear to have developed because of discrepancies between the intent of the Congress in enacting mineral land legislation and the intent of the Executive Branch department responsible for the administration of the laws. In balance, the weaknesses of all three existing public mineral lands systems currently in operation in the United States are far greater than the strengths of those systems. There is little doubt that changes must be made.

The combined weaknesses and strengths of the existing systems under which the search for and utilization of nonfuel minerals on the public lands of the United States must take place have resulted in a number of major issues regarding public land mineral policy. The first of these issues is basic to the entire problem and involves the decision to treat all public land minerals under a single comprehensive piece of legislation or to deal with the issues on a piecemeal basis. This concerns all of the various distinctions that have been made in the past on the basis of commodity, state, nature of original title (i.e., public domain or acquired), and the agency responsible for surface supervision. It also concerns the problem of how specific to make such legislation and whether or not all or some of the judicial doctrines established over the past 100 years should be made part of the statute law.

The second vital issue involves the attitude of the federal government towards its status as owner or trustee of the mineral resources of the public lands and its position as sovereign, landlord, or representative of the people of the United States. The position taken will directly influence the basic decision as to whether title to the mineral resources on the public lands should be transferred to the private sector, transferred to state or local government, or retained by the federal government. This also involves a decision regarding the exclusion of minerals exploration, development, and production from certain public lands and the basis on which such exclusion (if any) should be made.

Such a decision involves a number of other issues. If it is determined that minerals should be utilized principally by the private sector, then there must be a decision as to whether mineral rights should be transferred from the federal government by means of a claim and patent system, by a leasing system, by a sale of land, minerals, or both, or by some combination of methods. Also requiring resolution in this respect is the issue created by the severance of mineral rights from surface rights. It must be determined whether minerals will be severed from surface rights, and if so, in what manner and under what circumstances. Furthermore, the issue of disposal or retention of existing mineral rights reserved to the federal government must be considered.

Closely related to the general issue of method of transfer of mineral rights from the public to the private sector is the more specific issue of payment for those rights. There must be a decision as to whether such payment should be nominal, designed to encourage (or restrict) mineral resource utilization, based upon surface land values or based upon some attempt to appraise the value of minerals in place. (See Chapter 5 of the basic report.)

Particularly within the last three decades, the issue of federal agency jurisdiction has become of ever increasing concern. The entire issue involves several critical decisions. It must be decided whether one agency or several shall be responsible for the administration of minerals policy on the public lands. The extent of the discretionary authority given to such agency or agencies must also be determined.

FOOTNOTES

28/ For a complete description of the minerals location system, see Howard A. Twitty and George S. Reeves, *Legal Study of the Nonfuel Minerals*, pp. 283-720.

29/ See Twitty and Reeves, *op. cit.*, pp. 721-902.

30/ See Twitty and Reeves, *op. cit.*, p. 678.

CHAPTER 17

ALTERNATIVE PUBLIC LAND SYSTEMS

Are there any alternatives to existing public land policy? Would they have differing effects on the utilization of the nation's nonfuel mineral resources?

A. A GENERAL FRAMEWORK OF ALTERNATIVE SYSTEMS

1. Criteria

In devising and considering the possible alternative mineral land systems that might be applied to the public lands of the United States, it is necessary to first develop certain basic criteria with which to measure those systems and their features. These criteria may be classified generally into four groups: (1) technological criteria; (2) economic criteria; (3) legal and administrative criteria; and (4) political criteria.

The technological criteria used in the evaluation of any alternative system or feature would be numerous but would all essentially concern the same question: *Do the provisions of the law conform with and reflect a recognition of physical reality in the occurrence and utilization of mineral resources?* More detailed criteria could also be developed in accordance with geological reality and the existing and expected technologies of mining, beneficiation, and advance processing, as well as related physical sciences and engineering disciplines. Any alternative system or legal provision could thus be judged on the basis of its relationship to physical reality and its expected impact upon the mineral industries, the mineral resources themselves, and also upon the utilization of other natural resources on the public lands.

The economic criteria used in the evaluation of any alternative system or feature would be similar to the technical criteria. These criteria would be concerned, however, with two questions: (1) *Do the provisions of the law reflect a recognition of economic reality?* and (2) *What will be the economic impact of the law?* More detailed criteria could also be developed, of course, with respect to the particular economic sector involved. Any alternative system or provision could thus be judged on the basis of its relationship to economic reality and its possible effects upon the various economic environments.

The legal and administrative criteria used in the evaluation of any alternative system or feature would be numerous and complex. The strictly legal criteria are beyond the scope of this study and the competence of its authors. The administrative criteria, however, are relevant and involve two basic questions: (1) *Can the law be administered?* and (2) *What are the effects of the law upon the administrative structures of existing governments?* The list of detailed criteria that could evolve in answering these two questions could be voluminous. Essentially, the use of such criteria would permit the assessment of any proposed alternative system or feature on the basis of its administrative workability and its relationship to existing administrative procedures and structures at all levels of government.

The development of political criteria for the evaluation of proposed alternative systems and features is the proper prerogative of the Congress and beyond the scope of this study. Such criteria should not be neglected, however.

2. General Systems

Almost any alternative mineral land system or collection of features may be grouped into several broad categories defined by the basic orientation of or philosophy behind the law. The following generalized classifications and the major systems within each have been based on two essential concepts. The first involves the distinction between government and private ownership, while the second involves the opposing tendencies of monopoly and competition. Using these two concepts, four basic combinations can be derived: (1) government-monopoly; (2) government-competition; (3) private-competition; and (4)

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private-monopoly. Since government is by its very nature monopolistic in its functions, th second combination is somewhat unrealistic. Nevertheless, these categories do provide framework within which alternative public land systems may be developed and evaluated.

In the first conceptual category would be systems stressing government ownership an control of mineral resources in a non-competitive situation. The most extreme alternativ under this system would be federal ownership and control of all nonfuel mineral activity o the public lands. A somewhat modified alternative would entail federal ownership an control of all nonfuel mineral exploration and development with privately operate production of federally owned resources under contract to the federal government. A further modification would consist of federal ownership of all nonfuel mineral resources with all exploration carried on by federal authorities, but development and production by private entities under federal contract or franchise. An alternative with even greater latitude would involve federal ownership of all nonfuel mineral resources with exploration, development, and production by private entities under contract or franchise. This last is esentially a statement of the leasing system that currently is used for fuel minerals. Of course, there could be numerous variations of these systems, but all would be essentially based on federal ownership of all nonfuel mineral resources and the utilization of those resources under the direct control of the federal government.

An attempt to inject an element of competition would result in systems stressing government ownership and control of mineral resources in a partly competitive situation. An obvious alternative to be included in this category would involve federal ownership and control of all nonfuel mineral resources with production by both governmental and private entities. Even more competition could be obtained under a second alternative, with federal ownership and control of all nonfuel mineral resources but with both development and production by both governmental and private entities. Carrying this further, still greater competition could be obtained by having federal ownership and control of all nonfuel mineral resources with exploration as well as development and production performed by both governmental and private entities. Of course, the greatest amount of competition could be achieved in this group by a fourth alternative involving federal ownership and control of selected nonfuel mineral resources with all exploration, development, and production by both governmental and private entities. Variations of these systems would also be possible, depending upon the specific features of each.

A shift away from government ownership would lead to systems stressing private, competitive enterprise. The most distinct alternative in this general category would have all nonfuel minerals exploration, development, and production performed by private entities from lands which have been transferred from public to private ownership as their resources are discovered and developed. A modification of this alternative would entail all nonfuel minerals production and development by private entities on lands which have been transferred from public to private ownership, with exploration performed on both public and private lands by private entities. A further slight modification of this second alternative would have all nonfuel minerals development and production performed by private entities on lands which have been transferred from public to private ownership with exploration performed on both public and private lands by governmental as well as by private entities. An even stronger shift back towards government involvement would result in an alternative in which all nonfuel minerals development and production would be by private entities from lands which are partly private and partly public, with exploration performed on both public and private lands by both governmental and private entities. This last system is essentially the one under which the United States operates at the present time.

An unchecked increase in the apparently strong tendency toward monopoly in private (and public) enterprise would yield systems stressing private, non-competitive enterprise. The most extreme alternative in this group would have all nonfuel minerals exploration, development, and production carried on by private entities holding exclusive commodity franchises from lands which have been transferred from public to private ownership upon request. A modification towards government rather than private ownership would result in an alternative in which all nonfuel minerals development and production would be by franchised private entities from lands which have been transferred from public to private ownership upon request, but with exploration performed by franchised private entities on both public and private land. An even stronger shift towards government participation would give an alternative in which all nonfuel minerals development and production would be by franchised or otherwise privileged private entities from lands transferred to private ownership upon request, with exploration by both private and governmental agencies on both public and private land. Further injecting elements of both government and competition would yield an alternative system with all nonfuel minerals development and production being by privileged private entities from lands partly private and partly public, with exploration on both public and private lands by private and governmental entities. Of course, there could also be variations of these systems derived by varying specific features.

In any classification of concepts, there are always some that do not quite fit. Here, these must simply be referred to as other systems. One such miscellaneous alternative would entail complete cessation of all nonfuel mineral activity on the public lands of the United States. Another alternative would do the opposite, in requiring complete transfer of all public lands to the private sector. A modification of this alternative would involve the complete transfer of all public lands now held by the United States to the several states in which they are located. This last, of course, would merely shift the system actually adopted to the state level from the federal and would probably result in at least 11 different systems which could be classified generally into one or another of the four major categories already described.

B. VARIABLE FEATURES OF MINERAL LAND SYSTEMS

While alternative mineral land systems may be categorized and discussed in general terms, the specific features of those systems actually determine their workability and relevance. For detailed examination, these specific features may be divided into 12 major dimensions.

1. Tenure Status

Any alternative mineral land system may vary considerably according to the *tenure status* of both the surface lands and the minerals thereon. Both surface and minerals may be owned by the federal government, or both surface and minerals may be owned by the state or local government appropriate to their situation. Then, too, both surface and minerals may be owned by private entities, either individual or corporate. Greater variation is achieved by severing surface from mineral rights, and the surface may be owned by private interests with the minerals and/or subsurface owned by the federal government. Similarly, the surface may be owned by private interests with the minerals and/or subsurface owned by the appropriate state or local government. A combination of government ownerships may result where the surface is owned by a state or local government with the minerals and/or subsurface owned by the federal government. It is also possible that the surface may be owned by a state or local government with the minerals and/or subsurface owned by private interests. Although certainly not a usual situation, it could also be that the surface may be owned by the federal government with the minerals and/or subsurface owned by private interests, or the surface may be owned by the federal government with minerals and/or subsurface owned by a state or local government. And, of course, under each of such variations the owner of either surface, subsurface, or minerals might either *rent* what he owns to another or *grant* user rights to another, thus creating another series of alternative features, depending on whether the owner were to keep, rent, or grant. Such variations are often the result of the multiplicity of applicable legislation and administrative actions. They have in turn resulted in administrative weaknesses and problems in the multiple use of the public lands.

2. Processes Involved

In the utilization of mineral resources, the various stages of the search for and production of those resources provide an important dimension that can undergo substantial variation. Under any alternative mineral land law, *exploration, development, production,* and *post-production* activities may be considered together, or each may be considered separately. In a rough separation, post-production activities may be considered separately from the other stages. Similarly, actual production activities may be considered separately from the other stages or development activities may be considered separately from the other processes. Perhaps more realistically, exploration activites may be considered separately from the other stages of mineral resource utilization. In even greater detail, the three phases of exploration (*regional reconnaissance, target area examination,* and *deposit evaluation*) may each be considered separately, or the three phases of production (*mining, beneficiation,* and *advanced processing*) may each be considered separately.

In what appears to be the most logical breakdown, *regional reconnaissance, other exploration, development, production, and post-production* activities may be considered separately. In order to achieve an even greater degree of variability, any two or more adjacent processes could be combined for consideration separately from the other activites. This would provide a range of several hundred possible alternative features.

Many of the existing distinctions between processes are the result of tax legislation, not public land law. Such distinctions have not always been consistent with either technical or economic reality. Nevertheless, such consistency is possible.

3. Geographic Considerations

One of the most important dimensions involved in any treatment of the public lands (or any land) must be geographic, for this is the very nature of the subject. One of the principal variations of this dimension is that all public lands be considered alike. If a legal influence is allowed to prevail, then original public domain may be distinguished from acquired public lands. If political influence dominates, then public lands may be distinguished according to the state in which situated. If both influences are strong, then public lands may be distinguished both by the state in which situated and by status as acquired or original public domain. On the other hand, if more geographical criteria are used, then public lands may be distinguished according to the region in which situated, e.g., the Pacific Northwest, the Southwest, west or east of the 105th Meridian, the Mountain West, the Great Plains, Applachia, or on the continental shelf.

Multiple influences may be pertinent, in which case public lands may be distinguished both by the region in which situated and by status as acquired or original public domain. Since mineral resources are particularly relevant, public lands may be distinguished according to geologic provinces in which situated. If environmental factors rule, however, then public lands may be distinguished according to climatic zones in which situated. There are, of course, many other possible variation. Such variations can be consistent with reality, or, as in many instances in the past, they can ignore all but political reality. This has caused numerous problems in minerals exploration.

4. Agency Considerations

Since the administration of the law must be a critical factor in any public land law, then the *agencies* responsible for that administration form a vital dimension of the law. Under one possible alternative, all public lands may be considered alike regardless of the federal agency directly responsible for their administration. In the past, however, agency distinctions have been more common. Thus public lands under the administrative jurisdiction of the Bureau of Land Management have been and may be distinguished from other public lands. Similarly, public lands under the jurisdiction of the United States Forest Service may be distinguished from other public lands, just as public lands under the jurisdiction of the National Park Service may be distinguished from other public lands, and public lands under the jurisdiction of the Bureau of Sports Fisheries and Wildlife may be considered different from other public lands. It is also possible that public lands under the direct jurisdiction of the Atomic Energy Commission may be distinguished from other public lands regardless of their specific use or the purpose for the assignment of such jurisdiction. More closely related to land use, the federally owned lands under the jurisdiction of the Department of Defense may be distinguished from other federally held lands, while federally owned lands under the management of the General Services Administration may be considered different from other federally controlled lands. Likewise, it is probably almost a necessity that lands under the administration of the Bureau of Indian Affairs be distinguished from lands administered by other federal agencies.

Not nearly so substantiated by other conditions is the possibility that public lands under the jurisdiction of agencies within the Department of the Interior be distinguished from other public lands. Greater variation in the agency dimension is, of course, possible if public lands administered by any two or more federal agencies are distinguished from public lands administered by any other federal agency or groups of agencies. This could create a range of several hundred possible alternatives. Such distinction in the past has led to serious administrative weaknesses and even more severe inconsistencies between the law and geologic reality. The most noteworthy existing example lies in the differences in jurisdiction between the Bureau of Land Management and the Forest Service.

5. Commodities Involved

One of the most important dimensions in mineral land systems that has received considerable attention in the past is the *commodity* involved in the law. Under the simplest alternative, all mineral commodities may be considered alike. Under one of the simplest of traditional divisions, fuel minerals may be distinguished from nonfuel minerals. Then however, definitional problems arise, and fuel minerals may be considered to include only fossil (or carbonaceous, or combustible) fuels, while on the other hand, fuel minerals may include uranium, or even be so broadly defined as to include geothermal steam. In another traditional variation, metallic minerals may be distinguished from nonmetallics. Similarly, but more accurately, minerals which are important principally as a source of a metal or some other element may be distinguished from industrial minerals, which are important primarily as chemical compounds or for their natural physical properties. In probably the most realistic variation of all, fluid minerals may be distinguished from "hard" minerals. A modification of this would distinguish mineral commodities which normally occur in an unconsolidated state from mineral commodities which occur in a solid state. Thus, sand would be distinguished from quartz in veins. Similarly, mineral commodities may be distinguished according to their propensities to move within the earth's crust either naturally or as a result of efforts to extract them. Petroleum and natural gas would therefore be distinguished from coal. Although it is completely unrealistic, minerals may be distinguished from rocks. This, in effect, has been done in both statutes and judicial decisions. More closely tied to reality would be an alternative in which mineral commodities might be distinguished according to their normal geologic modes of occurrence. The lode vs. placer distinction was an early attempt at this, but it is no longer appropriate.

Even greater variations are possible if the technology of minerals utilization are considered. Thus, mineral commodities may be distinguished according to the methods of production most commonly used in extracting them from the earth, or mineral commodities may be distinguished according to the methods most commonly used to find them. More closely related to scientific reality, mineral commodities may be distinguished separately or grouped according to their chemical content. Likewise, mineral commodities may be distinguished according to their physical properties. If geological considerations become stronger, then mineral commodities may be distinguished according to their frequency of occurrence. Under more pragmatic influences, mineral commodities may be distinguished according to their value or according to their end uses. Then, too, it is always possible that mineral commodities may be considered distinct one from another according to any two or more of the criteria mentioned, thereby providing an extremely high range of possible alternatives in any mineral land system.

6. Monetary Considerations

The economic factor must be strong in any alternative system of mineral land law. As a result, *money* becomes an important measure of one vital system dimension. As one alternative, payments for minerals may be made on the basis of the value of the product, e.g., as a commodity purchase price. Conversely, payments for minerals may be minimal. Under another variation, payments for minerals may be made on the basis of the land area involved, or payments for minerals may be made on the basis of time, e.g., as a rent.

Basic objectives may become involved, so that payments for minerals may be designed to maximize the current revenue of the federal government, or they may be designed to maximize the long-term revenue of the federal government. Similarly, payments for minerals may be designed to affect federal government revenues from sources other than public lands (e.g. taxes). Methods may also become important in which payments for minerals may be determined on the basis of competitive bidding. Results may prove more important than either objectives or methods, however, so that adjustments in payments may be made related to various performance requirements. Numerous combinations of the above features may be utilized, of course, giving an extremely wide range of monetary alternatives. Within each alternative, the range of actual dollar amounts involved may also be varied widely. Such variation already exists, from the zero fee paid for an unpatented lode claim to the millions of dollars paid (and sometimes lost) for mineral leases.

7. Time Considerations

Time is one of the basic dimensions of any legal system, and so it must be with any system of public land mineral law. As one possible variation, the time spans involved in any alternative mineral land system may be related directly to the average times prevalent in the several stages of mineral resource utilization. Time spans may be made precise, or they may be expressed as ranges, i.e., as minima and maxima. Similarly, time spans may be lengthened to provide maximum protection to mineral resource finders and users, or they may be shortened to provide incentives for early performance. Then, too, time spans may be made adjustable in accordance with other variables. And, of course, several combinations of these may be used to provide a wide variety of alternative features.

8. Space Considerations

When dealing with land, *space* is undoubtedly the most fundamental dimension to be considered. In many respects, land is space. Nevertheless, in developing alternative public mineral land minerals systems, space considerations may include depth as well as surface area, or they may include only surface areas. As such, space considerations may be expressed in areal (e.g., 20 acres) or volumetric terms or by precise dimensions (e.g., 1500 feet by 600 feet). Measures may be exact or may involve ranges, minima, or maxima.

Regardless of how measured or stated, the amount of space involved may be related directly to the actual space requirements prevalent in the several stages of mineral resource utilization. In addition, the space involved may be related directly to existing political and/or federal land survey lines. Depending upon the objectives of the law, the amount of space involved in any mineral land system may be maximized or, conversely, the amount of space involved in any mineral land system may be minimized. It is most likely that, in any event, space considerations will be made adjustable in accordance with other variables, and, of course, several combinations of space considerations may be used in any mineral land system.

9. Obligations of the Federal Government

Although often only considerable in rather vague terms, the mutual obligations of landowners and users form a vital dimension in any public land system. As one variation of this dimension, the federal government may have obligations regarding the provision of access to public lands for minerals exploration, development, and production. Conversely, the federal government may also have obligations regarding the prevention of access to public lands for unlawful purposes. In either case, the federal government may have obligations regarding the protection of both nonmineral and mineral users of the public lands. As an owner, the federal government may be obligated to assure tenure to mineral users in accordance with other variables. But as a sovereign, the federal government may have obligations regarding the provision of information about the public lands.

10. The Rights of the Federal Government

Landowners do not have only obligations. They also have some rights, and the government is no exception. Under any alternative land system, these rights must be considered, and they can vary. The federal government may have the right to require a specific amount of accomplishment with respect to mineral exploration, development, and production activity by a resource user. Converesly, the federal government may also have the right to prohibit certain activities on its land, just as the federal government may have the right to require the control of effects upon the environment by mineral resource utilization. As a sovereign, the federal government may have the right to require access for nomineral users of the public lands, and it may have the right to obtain information about the mineral resources on the public lands. The amount and nature of such information would add additional variability to this dimension.

11. Obligations of the Mineral Resource User

Rights and obligations do not apply solely to landowners, but are equally applicable to tenants or users of the land. Under any system of public land mineral law, the mineral resource user may be obligated to perform specified amounts of exploration, development, or production work, and he may be required to provide certain information to the federal government about that work or its results. Furthermore, the mineral resource user may be required to control the effects of his activities upon the environment, and he may in fact be prohibited from engaging in certain activities. Because he is using public land, the mineral resource user may be required to permit access to other users of the public lands. Because he is dealing with the federal government, the mineral resource user may be required to follow certain procedures (e.g. file a claim) in order to gain the right to remove mineral resources from the public lands.

12. Rights of the Mineral Resource User

Offsetting the obligational dimension of any public land minerals system would be the rights of the mineral resource user. Under the various possible alternatives, the mineral resource user may have the right to remove one or more mineral commodities from the public lands. Furthermore, the mineral resource user may have the right of access to the public lands for exploration, development, and production. In addition, the mineral resource user may have the right to use the surface of the land for certain activities, specified or unspecified. Closely related to this, the mineral resource user may have the right to use other than mineral resources (e.g., timber) on the public lands. The mineral resource user may have the right to exclude other users of the public lands, and he may have the right to certain information about the public lands. In general, the mineral resource user may have the right to tenure on the land in accordance with other variables. These variations in the obligations and corresponding rights of the federal government have caused most of the serious issues involved in the utilization of mineral resources on the public lands.

C. EVALUATION OF SELECTED ALTERNATIVES

1. One Public Lands Mineral Law

One of the principal alternatives to the existing public lands mineral system would be the enactment of a single law concerning all mineral-related matters on the public lands. The most all-inclusive version of this alternative would contain provisions relevant to all subsurface resources, including subsurface water. Within the assigned jurisdiction of this study, however, the extreme alternatives considered would only encompass all nonfuel minerals (including uranium). The alternative would involve repeal of all existing legislation that has been detailed in the legal study of the nonfuel mineral resources by Twitty, Sievwright, and Mills, and would replace the existing collection of such laws with a single nonfuel mineral law pertaining to the public lands and with sufficient specific detail to avoid the need for enabling legislation in the various states.

The implications of this alternative are numerous. The federal administration of the public land law would be greatly simplified as a result of the replacing of numerous separate items of legislation with a single law. It is true, of course, that the many court decisions and administrative regulations that have been formulated in conjunction with the administration of existing legislation would no longer be valid. Nonetheless, a law could be written so that those portions of the existing judicial and administrative law considered desirable could be explicitly incorporated into the new legislation. Furthermore, it would probably not be long before new court contests would arise to establish a new set of judicial decisions, and there is no doubt that administrators within the federal government would very quickly establish new sets of administrative rules and policies.

A single federal minerals law would have implications for state and local governments, as well as for the federal government. The impact of a single federal minerals law for public lands would probably be felt most at the state level. Such a law, if made specific enough, and depending upon its specific features, could in effect nullify the various state laws regarding the acquisition of mineral resources on the public lands and restrict their application only to lands actually owned by the states or other appropriate local jurisdictions.

The effects on the economic environment of a single federal minerals law would depend primarily on the actual provisions of that law. Such a law could, of course, simplify government procedures and thereby lower government costs, and as such it would have a definite impact upon the public sector of the nation's economy. The impact on the regional economy and the numerous local economies of the West, would also depend upon the specific provisions of the single law. The same would be true of the effects of a single law upon the physical and social environments in which nonfuel mineral resources are utilized. The same could be said of the effects on the relationships between mineral resource users and other resource users on the public lands.

The effects of a single minerals law upon the minerals industries themselves would be essentially twofold. First, the major effect would be to simplify mineral acquisition and eliminate the need for determining what is a locatable and what is a leaseable mineral. Having a single mineral law, however, would not necessarily mean that the distinction between locatable and leaseable minerals would be obliterated. If it were, in fact, felt desirable to maintain this distinction because of certain characteristics that were considered valid (at least at one time) as criteria for such distinction, then they could be incorporated into a single law. The essential effect of the one piece of legislation would be to simplify and (hopefully) eliminate some of the inconsistencies presently existing between laws dealing with different minerals that were enacted at different times for different purposes. The greatest impact of a single law on the mineral industries would, however, depend upon the more specific provisions of that law. Simply the establishment of one law in place of many would not necessarily change the major provisions of those laws.

The effects of a single minerals law on the mineral resources of the public lands themselves would likewise depend upon the specific provisions of that law. The considerations of all minerals under a single piece of legislation, however, would be a significant step in the direction of making the law consistent with geologic reality.

There are, of course, possible variations of this alternative. One of these is to leave much as they are the collection of miscellaneous laws now in existence. This would leave one law dealing with *locateable* minerals, one law dealing with *leaseable* minerals, one law dealing with *disposable* minerals, and various other laws dealing with relatively minor facets of public land minerals policy. The implications of this should be rather obvious. They would perpetuate the existing inconsistency between the law and geologic, technical, and economic realities, and they would continue the administrative confusion, overlap, and inconsistencies that now exist.

In the other direction, the placement of all minerals and subsurface waters (in effect all subsurface resources) under one public land law for subsurface resources would perhaps be somewhat extreme. There are real differences between those subsurface commodities, such as water, oil, gas, steam, and helium (which can flow from the site of their original location to another point without regard to property lines or political boundaries) and those minerals which are normally found in a solid state. Perhaps inclusion of all of the *flowable* minerals with the *hard* minerals under a single law would be a step away from the needed consistency between the law and geologic reality. The inclusion of dissimilar problems and dissimilar commodities under a single piece of legislation could, rather than simplifying administrative procedures, further complicate and obscure them.

The principal result of the establishment of a single public land minerals law, at least for most nonfuels and coal (or at least for most of the hard minerals), would be the simplification of federal administrative procedures and the facilitation of mineral resource use. Further effects would depend entirely upon the specific provisions of that law.

2. Disposition of Reserved Mineral Rights Now in the Public Domain

Probably the most basic question involved in the utilization of mineral resources in the public domain involves whether or not these minerals should be subject to disposition, management, or retention. One alternative to existing policy and law would be to have all mineral rights presently severed from surface rights and reserved to the federal government sold to the owner of the surface rights. This alternative would deal directly with the existing and potential problems caused by the severance of surface rights from mineral rights on lands, the surface rights to which have left federal ownership. One logical alternative for dealing with reserved mineral rights would involve the sale of such mineral rights to existing surface owners for a nominal sum, perhaps equivalent to or less than the existing $5.00 per acre involved in the patenting of lode claims. This would eliminate any need for estimating the value of such rights or the existence of subsurface vaues. (See Chapter 5.) A logical second step in this alternative is that mineral and surface rights hereafter would not be severed, as far as the federal government was concerned. In other words, *those individuals or firms receiving title to mineral rights on the public lands would also receive title to the surface rights*. Similarly, *those firms or individuals receiving title to the surface rights hereafter would also receive title to the mineral rights beneath that surface.*

Such a practice, if adopted, would immediately lead to the removal from the public domain of large areas of presently reserved mineral rights situated underneath privately owned surface lands throughout the 11 Western States. A problem could arise, however, where the surface owners of large areas would not want to pay for the mineral rights under their holdings, because even a nominal per acre sum could become a substantial amount, if multiplied by enough acres. In such a case, it might be well to develop a sliding scale of fees or perhaps introduce an even smaller fee than the $5.00 an acre now involved in mineral patents. Such a scale might involve a fee of $5.00 per acre for 40 acres or less and range down to 25 cents per acre for acres of 1,000 acres or more.

The implications for the federal government of this alternative would be several. First, the sale of mineral rights would bring an immediate increase in revenue to the federal government. Over the longer run, however, the direct effect would be a reduction in the income received from the leasing of federally owned minerals now held under private surface land. Another impact on the federal administration of public land minerals would be a simplification of that administration in that the law would apply hereafter to areas in which both surface and mineral rights were owned by the federal government, and the problems arising from distinctions between surface owners and federal ownership of the subsurface would be eliminated.

The impact of the alternative on state and local government would be generally beneficial and would be similar to the effect on private owners of the surface land. In many respects, the various state governments would become the owners of significant areas of mineral resources now located underneath areas on which the states own the surface rights, but do not own the mineral rights. For many local governments and for state governments as well, the alternative would mean an increase in the tax base, because of the addition to total real property of the mineral resources presently reserved to the federal government.

The effects of this alternative on the national economy would be difficult to measure, but they would be felt primarily through the public sector. First, there would be an increase in immediate governmental revenue caused by the sale of subsurface resources. Second, there would be a decrease in the income received from mineral leasing. There would also be secondary economic effects, however, caused primarily by the reduction in size of the areas open to minerals exploration and acquisition under either public land location or leasing procedures. Such an impact might be far more widespread and significant than the immediate impact through public sector revenues. This would also be the case for the effect of this alternative on state and local economies. Although the tax bases of such local economies would immediately increase, and public revenues would be increased in the short term, the reduction in the amount of public land available for minerals acquisition through the location and leasing procedures could have an adverse effect on total mineral resource development, and thus restrict development in many of the local economies of the West. This, of course, would also have a long-term adverse effect upon state and local public revenues.

The influences of this alternative upon the physical and social environment would be various. In most respects, this alternative would eliminate any control by the federal government over the direct effects on the nonmineral environment caused by mineral resource users, at least through the public land laws. This is not to say, however, that environmental controls could not be exercised through other means such as specific air or water pollution legislation. Such a distinction would probably be advantageous for the government, the public, and natural resource users alike, in that there would be no mingling of purposes within the same law. The effects of this alternative on nonmineral resource users of the public lands would probably be negligible, particularly in areas where other resources already have had access to the surface. It would most certainly eliminate much of the potential conflict between mineral resource users and surface owners in those areas where subsurface and surface rights have been severed. Although this has not been serious to date, the problem potential, particularly in the urbanized areas of many Western States, is very real and perhaps more immediate than is realized.

The effects of this alternative on the mineral industries now operating on the public lands would be to restrict the areas under which they could acquire new mineral resources under either the location or leasing procedures of existing public land mineral law. It would, in effect, place greater mineral areas into the private sector and could increase the problems of future mineral resource acquisition for minerals producers. On the other hand, for those firms or individuals later acquiring mineral resources from the public lands, it would make available to them complete ownership of the surface as well and thereby considerably simplify many of the problems that now exist with unpatented mining claims and in mining on land where the surface is still controlled by the federal government.

The effect of the alternative on mineral resources would be similar to that on the mineral industries that are (or would be) utilizing those resources. Probably the greatest impact would be the reduction in potential mineral reserves because of the decrease in accessibility to those reserves caused by placing them under private ownership. In many areas of the West, this would duplicate the situation now found in the non-public land areas of the remainder of the United States. There, it has become increasingly difficult to acquire potential mineral lands at a reasonable price, even for exploration. This could have serious consequences for the economy of the nation as a whole.

There are, of course, variations to this alternative. One of these is that all mineral rights hereafter would be reserved to the federal government regardless of the disposition of the surface rights of the public domain. This alternative would, of itself, not eliminate any of the problems caused by existing or potential conflicts between mineral resource users and other users of the surface rights presently held under private ownership. It would, however, guarantee access to the maximum extent of mineral resources currently held in the public domain.

A third variation of this alternative would be to consider ownership rights to public land in terms of *depth* rather than *content*. In other words, mineral rights as such would not be involved, but those present surface owners might have to receive title to all rights down to a certain depth (say 1000 feet or 5000 feet) below the original surface. Hereafter, even if mineral rights were disposed of separately, they could include a vertical dimension, rather than simply area and commodity dimensions. Such a variation would undoubtedly be more consistent with geologic and technical reality in dealing with the conflicts that could come about between users of mineral resources and users of the surface. Most mineral deposits below 1000 feet from the surface would probably have to be removed by underground mining methods or other methods involving a minimum disturbance of the surface, whereas deposits within 1000 feet of the surface can now normally be removed by surface mining methods (which also remove the previous surface). Where the surface of the land is highly irregular, however, this designation of a depth dimension could be problematical. Then, too, it could cause a restriction in the access to near-surface deposits of certain minerals, and it could place increased emphasis on underground or solution mining techniques. It could also, however, seriously restrict the use of any caving methods of underground mining or other subsurface techniques which result in surface disturbance.

The attachment of surface rights to the acquisition of mineral rights from the public domain would eliminate, in many respects, the problem of unpatented, abandoned mining claims. Once mineral activities had ceased, the surface land would still belong to the person or firm who had acquired it for mineral purposes, to be used in any other manner consistent with other legislation. This property would be taxable, and as such, any abandonment could be cleared by due process of law under local procedures for nonpayment of taxes.

It would appear that the most logical variation of this alternative would be that: (1) hereafter, those who acquire mineral rights from the public domain also acquire the surface rights in fee simple; but (2) those who presently have only surface rights where mineral rights have been reserved to the federal government should not receive the mineral rights except for explicit and immediate minerals development. This combination of features would result in a maximum amount of mineral resources open to acquisition by mineral resource users, while at the same time eliminating many of the problems caused by the abandonment of exhausted mineral properties and the resultant problems arising from unclear titles to unpatented mining claims.

3. Unrestricted Minerals Reconnaissance on the Public Domain

This alternative procedure would allow mineral reconnaissance over all public lands without any restrictions except those that might be involved in the disturbance of prior surface usage where such uses are specified private or restricted special uses by the federal government. Such government uses would include (but not necessarily be limited to) sites for public buildings, national defense installations, atomic energy test sites, hydroelectric sites, and national parks and monuments. This alternative would permit what is, in many respects, already being done by air. It would also permit on-site geologic reconnaissance, but not detailed exploration. In other words, it would permit individuals searching for mineral resources to walk, ride, or fly over the public domain in search of surface mineral indications. Coupled with this free access to the public lands for mineral reconnaissance purposes, however, would be an absence of any prediscovery protection or preferential rights to those minerals for which surface indications or aerial geophysical indications might be found.

The implications of this alternative for the federal agencies responsible for the administration of the public lands are several. Such a provision in the mineral law would serve to open up many areas for minerals reconnaissance that are now closed or withdrawn from such activity. This would undoubtedly have an impact upon those agencies directly responsible for the administration of those areas. The law would also specifically define those areas closed to minerals reconnaissance, but in doing so, it would probably be necessary to provide justifiable reasons for restricting access to such areas. The specific elimination of any prediscovery rights resulting from reconnaissance activities would also enhance judicial processes, particularly with respect to the handling of litigation by conflicting claimants.

The impacts of this alternative on state and local governments are difficult to estimate. Direct effects would probably be nil. Indirect influences would probably be considerably greater, in that larger areas of the public lands would be open to minerals reconnaissance, and economic activity within the jurisdictions of various state and local governments would be increased. This would be the major impact on the regional economic environment as well. A longer term effect would result from the fact that greater amounts of mineral resources would be opened, not necessarily to physical acquisition by minerals producers, but at least to their acquaintance. The stimulation of reconnaissance activity in certain areas would have a definite, although probably a relatively small impact upon local economies in those regions.

The effects on the physical and social environment of permitting free access for minerals reconnaissance purpose to all areas of the public lands except those actually used by the government for specific government function would probably be negligible. There is virtually no effect on the environment from an airplane towing a magnetometer flying over a wilderness area. Nor is there much impact one way or another from the boots of a field geologist striding over open areas of a national park or wilderness area. With modern techniques, the effects on the physical environment of geophysical and geochemical surveys are literally almost unmeasurable without specialized instruments. They are certainly insigificant when compared to the effects of other public land activities. It should be borne in mind that, without any prediscovery protection, minerals reconnaissance activity would, of economic necessity, be kept to a bare minimum. As a result, the effect on nonmineral users of the public lands would also be minimal.

The primary effect of this open reconnaissance alternative on the mineral industries would be to increase the areas available for preliminary minerals exploration and, therefore, to increase the nation's potentially available mineral resources. For such an alternative feature to provide any really effective spur to increasing mineral exploration activity, however, it would have to be coupled with an opportunity for acquiring prediscovery rights toward any anomalies that might be encountered and a subsequent opportunity to develop and use any valuable mineral deposits discovered. Thus, it would probably be necessary to couple this alternative feature with a minerals exploration franchise system outlined in Section 4. Another possibility might involve a right of first refusal as part of a competitive bidding system. Most likely, however, the simple use of a first-come, first-served method of awarding detailed exploration franchises would assure sufficient protection to discoverers of anomalies during reconnaissance.

As far as the mineral resources themselves are concerned, the alternative would considerably increase the potential mineral resources of the United States. The feature would most certainly bring the provisions of the mineral law and policy on the public lands in much closer conformity with both technical and geologic reality. Economic reality would in turn minimize any tendency toward adverse effects that might result from the operation of this policy.

4. Detailed Minerals Exploration Under Franchise

Under this alternative, detailed minerals exploration (including *target area examination* and mineral *deposit evaluation*) would be permitted on the public lands under an exclusive exploration franchise designated for a specific area for a specific period of time. Any franchise would be awarded on a first-come, first-served basis for a minimal per acre fee. For the subsequent utilization of any mineral resources discovered under an exploration franchise, preference would be given to the current franchise holder.

The procedure used in this alternative would require any individual or firm interested in the detailed exploration of a specific public land area to apply for a detailed exploration franchise for that area. The franchise would be for a specific period of time, probably from one to two years, and renewable for additional periods of from one to two years. A variation might make the franchise renewable every six months. It would be necessary for the holder of an exploration franchise to perform a certain amount of detailed exploration work (measured in dollar terms) within the designated franchise area within six months of the awarding of the franchise or relinquish it. Subsequently, additional amounts of work would be required during each six months period.

The holder of an exploration franchise would be required to control any possibly detrimental effects of his activities upon the natural environment. All basic (but uninterpreted) information about the franchised public land area obtained by the holder of an exploration franchise would be made available to the federal government upon termination of the franchise or within six months thereafter. The holder of an exploration franchise would be required to permit access to the franchise area by other users of the public lands, so long as public safety and the security of personal property would permit. The holder of an exploration franchise would also be allowed to remove minor amounts of mineral commodities from the public lands designated in the franchise for testing purposes, but not for sale.

Any exploration franchise would involve all minerals. The maximum *contiguous* area initially involved in any one exploration franchise would be five townships, and there would be a fixed (though minimal) per acre fee for this amount. A fee of $1.00 per acre per year would not be unreasonable, or the fee might be made equal to the grazing rights fee for the same land. Under the alternative, it would be necessary for the franchise holder to reduce the area of the franchise every year, or at least pay a higher per acre fee. For example, after one year it might be made necessary to reduce the franchise to a maximum of five contiguous sections, or the per acre fee might be doubled. It would be necessary, even if the area were not reduced, to increase the per acre franchise fee in order to prevent excessive speculative land holding under any one exploration franchise. Upon each franchise renewal date, the amount to be paid per acre could be increased, even without area reduction, for a five-year exploration period maximum. This would allow a legitimate minerals exploration firm to concentrate its effort on its most likely exploration target and begin intensive mineral deposit evaluation. Any exploration franchise area would be in multiples of forty acreas, i.e., in multiples of quarter, quarter sections.

The implications of the exploration franchise procedure would be many and varied. The alternative would eliminate the mining claim as it is known today. It would also eliminate the use of production leases during the exploration phase. There would thus be no problem of undefined, unpatented mining claims. Nor would there be the problem of unsurveyed or poorly surveyed claims and fractional claims, if the franchises would awarded for areas defined by the established federal land survey in multiples of quarter, quarter sections. This alternative would considerably simplify the administration of the public land laws with respect to mineral resources. It would also make the administration of the public lands simpler in that it would not required any distinction or classification of land as to mineral or nonmineral. If a firm or individual were to apply for an exploration franchise for a given area of public land and be willing to pay the per acre fee for that franchise (which would guarantee no rights other than access and preference in the utilization of deposits discovered, for a limited length of time) this would be considered *prima facie* evidence that the land was potentially the site of a valuable mineral deposit. The franchise would not grant exclusive use of the land surface, but would provide prediscovery protection.

The primary impact upon state and local governments would be at the county level, where the need for the recording of unpatented mining claims would be eliminated. Other impacts on state and local government of this alternative would be essentially indirect, through effects on economic and other environmental factors.

The alternative would have manifold effects in national as well as regional and local economies. It would first make exploration for mineral resources on the public lands rewardable and tenure more secure. This could stimulate the search for mineral resources of all types and thereby enhance competition in mineral markets. The stimulation of the search for mineral resources on a uniform basis throughout the public land states could have a favorable impact upon many of the local economies in areas enriched in potential mineral deposits or at least those areas considered geologically attractive. The restriction to a maximum size for a franchise holder in the placement of specific acreage and time limitations on single franchises, as well as the imposition of a per acre cost for the franchise, would tend to restrict monopolistic practices by minerals firms and enhance competition within the minerals industries. It would also severely limit, if not eliminate, the abuse of the mining laws for real estate speculation.

Specific requirements in the law regarding the effects upon the physical environment of exploration activities should delineate those effects considered adverse. The imposition of precise acreage limitations and per acre fees for an exploration franchise, as well as the exclusion of nonmineral surface use rights, would tend to restrict activities by those persons not seriously seeking a mineral deposit. In particular, the position of a relatively short-time limitation and the need for the performance of a specific amount of exploration work during any given time (if enforced) would tend to eliminate current abuses of the Mining Law of 1872 under which persons have used the pretext of a mining claim in order to gain the use of surface resources in selected areas. A requirement for the periodic reduction in the area included under any one exploration franchise would guarantee a maximum availability of land for both nonmineral users of the public lands and for other mineral users.

The alternative of a uniform exploration franchise with features as outlined should bring the public lands mineral law in closer conformance with the technical and economic realities of the mineral industries as they exist today and as they are likely to be for the next two decades. The area franchise concept is in conformance, not with the conditions of the 1860's, but with current exploration practice as it has been followed for the past two decades and as it is likely to be practiced for the next two. The franchise would give adequate prediscovery protection to the exploring firm or individual and would eliminate problems caused by vague titles to public land areas cluttered by the existence of unpatented claims whose status as abandoned or active is usually in question. It would eliminate the use of the lode and placer claim concepts and, in using a square or rectangular basic unit, be more in conformance with the structure of those orebodies being mined today, and with the land requirements of other mineral-producing activities. The use of a minimal per acre fee for the exploration franchise would allow exploring firms or individuals to put a maximum amount of their capital investment into the acquisition of information about the nation's subsurface resources and minimize the amount that could be lost in not finding an economically valuable deposit. At the same time, it would prevent the mineral industries from acquiring more land for exploration than they might actually need by making it increasingly more expensive for them to do so.

This alternative, with the features as outlined, would also bring the law into closer conformance with geologic reality. It would make potential resources available to those firms or individuals most likely to utilize them upon discovery. It should also lead to a maximum availability of information about the geologic nature of the public lands, and thereby a more efficient allocation of total resources.

There are, of course, many variations possible for this alternative system. Specific features could be expanded, restricted, or eliminated. The acreage limitaitons could be changed, the time limitations could be changed, and the monetary dimension could be varied considerably. Each of the variations in the basic features of this alternative system would have its own implications and would have to be considered specifically. Such specifics are far beyond the scope of this study.

There are also alternatives to the entire system as stated. One is to continue to allow completely open exploration without any prediscovery protection, that is, to continue the system established for mineral exploration under the Mining Law of 1872 for locateable minerals. Of course, even now the system does not actually operate in accordance with that law. A continuance of this procedure would result, of course, in the continuance of the problems that have been created under it. Nevertheless, some modifications of that system are possible and undoubtedly highly desirable. As a minimum, it probably would be advisable to require the federal registration of all unpatented mining claims, including submission to the appropriate federal agency of a plat map that is tied into the established public land survey. These should be registered with the nearest Bureau of Land Management office, as well as in the appropriate county recorder's office.

Another alternative modification would involve the use of an *exploration claim*, which would be distinct from a *mining claim* in that it would entitle the holder or claimant to remove minerals only for testing and evaluation. Specific work requirements would have to be attached to any system involving an exploration claim, however, in order to prevent excess land speculation for nonmineral purposes under the exploration claim device. In many respects, an exploration claim would be an irregular, open-ended, very-short-term exploration franchise at zero fee. The basic principles involved in both are similar.

At the other extreme, an alternative requiring the payment of a fee for any exploration rights on the public lands on a competitive bid basis for specific land areas could be considered. This feature, however, would tend toward monopolistic practices by restricting exploration to those firms and individuals with the most money, i.e., those firms already well-established. It would thus restrict entry into the industry and create a definite tendency toward monopoly with resultant adverse consequences for the entire economy.

It should be kept in mind that any exclusive franchise system, even when established on a first-come, first-served basis, is subject to administrative abuses. Care would have to be taken to minimize the potential for such abuses. Keeping the elapsed time between application for and issuance or rejection of a franchise to a matter of minutes, and keeping all records open to the public would substantially reduce the potential for abuse.

5. Land Acquisition for Minerals Production

One alternative for the treatment of public lands containing mineral resources (for the purpose of utilizing those resources) would be to permit any individual or firm desiring to produce minerals from the public land to purchase the land upon which those minerals are located. The price paid would be the appraised value of the *surface* resources. It would not involve any attempt to determine the value of subsurface resources, but these, in effect, are nil before development. Mineral resources are essentially created by mine development. (See Chapter 5.)

Preference in purchase for any given area would be given to the holder of an exploration franchise for that area. Any buyer of public lands for mineral purposes would be required to perform a specified amount of mine development work (excavation or drilling) within one year from the date of purchase or forfeit title back to the federal government. This alternative assumes, of course, that both the mineral rights and the surface rights for any given public land area are initially the property of the federal government. Under the alternative, no individual or firm would be allowed to purchase public land for minerals purposes without first securing an exploration franchise and conducting exploration operations under that franchise for at least one year.

The implications of this alternative for the administration of the public land law are that such administration would be essentially simplified. There would be no requirement for specific proof of discovery. Prediscovery protection would be provided by the prior exploration franchise. Desire on the part of the franchise holder to pay for the surface resources at their current appraised market value (irrespective of the presence of any mineral resources) would be *prima facie* evidence of mineral discovery. The results of the development work requirement would substantiate or refute it. The alternative could also eliminate a substantial amount (if not all) of the abuses of the present Mining Law perpetrated by those desirious of obtaining public land surface rights at a nominal fee. Of course, to eliminate these abuses, it would be necessary to establish the first-year development work requirement at a substantial amount and also to make it proportional to the area involved. An expenditure requirement of $100 per acre in actual development work would not be an unrealistic standard under current conditions.

The immediate fiscal impact upon the federal government of this alternative would be to reduce the amounts received from mineral lease payments, but to increase the amounts received from the development of what are now *locateable* minerals on the public lands. Although lease bonus payment revenues would be decreased, the money that had been paid to the federal government under such arrangements would probably be diverted to productive uses in the further exploration and development of mineral property. This would contribute to the more rapid development of mineral production and should result, within a very few years, in increased tax revenues to the federal government, assuming no prior offsetting changes in the tax laws.

The impact on state and local governments under this alternative would be immediate and primarily financial in nature. The purchase by private interests of lands formerly held by the federal government would increase the tax base in each of those states and communities in which the land is situated. The alternative would also eliminate the need for keeping records on unpatented mining claims in the individual counties throughout the public land areas of the United States. Furthermore, abandoned unpatented claims would be eliminated as a problem because any land abandoned after production operations by those firms or individuals owning that land would become forfeit under tax obligations to the various counties, and title could be cleared under established procedures for tax liens.

The impact of this alternative on the national economy would be twofold. The first would be in the financial portion of the public sector, in decased public revenues from leasing and bonus payments, but offset by increased tax revenues from profitable mineral-producing operations, as well as direct revenue from land sales by the federal government. The second facet of the impact of this alternative on the national economy would be to provide an incentive for a more appropriate allocation of investment capital, in placing in proper perspective both the surface and subsurface uses of any given piece of public land. Since the value of the mineral to be produced would have to be such as to compensate for the withdrawal of surface uses from their present status (if mining involved any surface disturbance), a better allocation of resources between competing uses of the public lands could be achieved.

At the state, local, and regional levels, the economic influences of this alternative would also have several aspects. One, as mentioned, would be through the public sector, in increasing the tax bases for state and local governments through the transfer of public land to private ownership. The second would be through the stimulus of mineral production where economically feasible and through the provision of incentives for obtaining the highest economic use of available land. In areas where metalliferous deposits are known or are considered likely to occur (i.e., in areas where the known mineral potential consists chiefly of minerals that are now *locateable*), the increase in mineral activity would probably be slight. Surface land uses would have to be given greater consideration in relation to subsurface uses, however, than is now the case. There is little doubt that considerable impetus would be given to the development of mineral resources in areas now devoted to the production of the so-called leaseable minerals. The optimum production of industrial minerals should also be stimulated by this alternative, however, under the consideration of proper allocation of resources between surface and subsurface uses of the land.

The requirement of this alternative, that the payment for lands containing mineral resources should take into consideration only the value of surface resources on that relevant land area, should considerably improve the relationships between the mineral resource user and the environment, both physical and social. This alternative would, in effect, force the quantitative measurement of competing uses of the land by transferring permanent ownership to the legitimate minerals producer. It would also enable and encourage the proper control of invironmental factors during and after production operations. (See Chapters 12 and 14.) Continued ownership of mineral-producing land after principal production operations have ceased has proved to be a strong incentive for the further development, reclamation, or conversion of mined-out land to its most productive use, i.e., that use which will provide the greatest income to the landowner. There would probably be little or no impact upon the relationship between mineral production operations and the physical environment during active minerals production. These environmental influences, however, can (and probably should) be taken care of under other legislation, specifically designed for that purpose. The problems of atmospheric pollution should be dealt with under specific legislation and not as part of land law.

The primary impact of this alternative upon nonmineral users of the public land would be to place in proper perspective (on a dollar basis) the value of nonmineral uses of the surface, and thereby allow these uses to compete in the open market for land. The alternative would also eliminate abuses of the existing mining laws by those persons who declare minerals intent only as a means to gaining title or access to the surface of the public lands or to other surface resources, such as timber, located on those lands. There would be little or no impact upon the users of adjacent public or private lands by this alternative. Elimination of the problem of unpatented and abandoned mining claims, however, would facilitate the use by other users of the public lands of surface lands not actually in mineals production by having those lands (once minerals production had ceased) revert to appropriate local public agencies or by allowing them to be resold to other private interests.

The major impact of this mineral land purchase alternative upon the nonfuel mineral industries would depend upon whether a particular firm or individual were now operating under the Mineral Leasing Act or under the basic Mining Law of 1872. For those firms or individuals producing minerals considered to be locateable,this alternative would force them to cease the use of the unpatented mining claim and to allocate sufficient funds for the purchase of all mineral lands that they would wish to use for minerals production and associated activities, in direct competition with other potential users of the public lands. Transfer of complete ownership of all subsurface and surface rights to the minerals producer would also encourage the maximum utilization of land held by the minerals producer, both during and after production operations. The fact that mineral-bearing lands would be held in fee simple would also assure the minerals producer and developer of complete protection of his rights in the further exploration and development of that land.

For those mineral producers operating under the leasing laws, the immediate impact would be to eliminate the necessity for competitive bidding on an unknown quantity, i.e., the placement of competitive bids for unexplored land. It would also (as under the locateable minerals) require such producers to give due consideration to the surface value of land used for mineral purposes and to the reclamation or conversion to a higher utilization of that land upon cessation of production operations. In both instances, that of both locateable and leaseable minerals, this alternative would restrict monopolistic tendencies towards the acquisition of more land than is needed for appropriate mineral development and production by forcing mineral producers to compete with other users of the land. In some instances, it would probably encourage the advancement of underground mining techniques or other methods of mining that would tend to cause a minimum disturbance of the surface. This would be particularly true where the value of surface uses were substantial.

This alternative, in some instances, would reduce the availability of mineral resources, particularly of locateable minerals, while at the same time increasing the potential reserves of leaseable minerals. In the first instance, reserves would be reduced by the requirement that the value of subsurface resources would have to be high enough to offset the value in other uses of the surface of the land. In the second instance, it would allow greater exploration and development without regard to excessive bonus payments, rentals, or royalties paid on industrial minerals land, particularly in areas of low surface value. In areas of potential multiple use of the land, such as those on which sand and gravel deposits are found in the fringes of established urban areas, the mineral land purchase alternative would probably increase the availability of mineral resources by allowing multiple returns to be made from a single purchase price of the land, i.e., from the extraction of the mineral resource itself and then from subsequent development for the surface use of the land. The alternative puts the law in much closer accord with economic, geologic, and engineering reality in permitting a proper allocation of values to subsurface and surface utilization of the public lands, and in eliminating the often inflated prices paid for unknown (and sometimes known) minerals under the bonus bid and leasing system.

There are, of course, a number of variations to this mineral land purchase alternative. One of the basic alternatives is the present system for locateable minerals under which ownership of minerals and use of the surface are obtained for mineral development purposes by the payment of a nominal fee or not at all. The results of this alternative on the environment, upon the federal government, upon state and local governments, and upon the mineral industries themselves have been recorded over the past 100 years. The nominal or zero payment for surface lands has certainly encouraged the development of nonfuel mineral resources, primarily of those metallic ores that are considered locateable. On the other hand, it has also led to abuses of the law by those desirous of obtaining surface rights through distortion of the mining laws that has frequently been permitted by administrative agencies and the courts. The payment of a nominal fee for mineral-containing lands does not allow the proper allocation of resources and priorities between surface and subsurface uses of the land. This has already caused some minor conflict in urban areas and is likely to cause much more conflict in the future. The other extreme variation of this alternative is not to transfer title in fee simple to the minerals producer, but simply to lease the desired mineral land to him for payment of a rental consistent with the value of either the surface resources or the surface and mineral resources combined on either a competitive bid basis or a first-come, first-served, fixed amount basis. The lease arrangement, if for a long enough term and if for a fixed amount, would be similar in many respects to a simple transfer of title in fee simple in many respects to a simple transfer of title in fee simple for a fixed purchase price paid in installments. If the lease is short-term, however, it removes from the owner some of the guarantees that he would otherwise have if the land were owned by him. Likewise, it removes some of the incentives for converting the land to the highest economical use once mineral producing operations have ceased. The lease arrangement also diminishes the tax base of state and local governments by not transferring any land to private ownership. Competitive leasing removes the protection accorded to the minerals explorer and developer and, in effect, removes any strong incentive for mineral development, except where the potential gains are extremely high. In such cases, the element of monopoly profits becomes extremely strong and tends to misallocate investment capital. This has already been the case in the petroleum industry.

6. Elimination of Distinction Between Public Domain and Acquired Public Lands

Under this alternative, all public lands would be considered alike, regardless of their location and regardless of their status as acquired or original public domain. Public lands on which the surface use by the federal government is specific with respect to governmental activity and thereby precludes mining activity (e.g., national defense installations, national parks and monuments, post office sites, etc.) shall not be considered *public land*, but shall be termed *federal land*. This alternative would simply remove from potential mineral development under any proposed or existing system those lands used for particular governmental purposes, that is, for those functions normally considered the prerogative of the federal government, such as national defense activity, governmental buildings, national parks and monuments, historic sites, and so forth. It would not include those lands on which (although the government may have control) the activities conducted thereon are normally performed by private enterprise. This would include primarily the National Forests and all those lands now administered by the Bureau of Land Management.

The direct impact of this alternative on the federal administration of the public land laws would be to simplify administrative procedures by removing the distinctions that now exist under various laws between acquired public land and public domain. It would, in effect, increase the public domain and make all policies and laws presently applicable to the public domain applicable to all public lands (except those designated *federal lands*). The alternative should, of course, allow also for transfer back to public domain of lands specifically reserved for such activities as national defense installations or atomic energy test sites, once those particular activities are no longer being conducted. This alternative would, in effect, make all public lands not used for specific government purposes subject to the public land mineral law alternatives discussed previously.

The effects of this particular alternative on state and local governments would be nil. The effect on the economy at the national level would be minor and would result primarily from the eliminantion of excess costs involved in the administration of the public lands, as well as in the elimination of certain revenues obtained from the sale or lease of mineral commodities from *acquired land* now held by the government of such minerals that are normally considered locateable under the existing *public domain* legislation. The effects on state and local governments would be essentially minimal and only those resulting from the revenue sharing practices related to revenues received from mineral production on acquired public lands.

The impact of this alternative on the physical and social environments under which the producers of mineral resources on the public lands operate would be nil. The effect on the mineral industries themselves would be to simplify exploration, land acquisition, and mineral development practice. The alternative would have virtually no effect on the mineral resources of the United States themselves, except to place those mineral resources on acquired land in the same political and legal status as those on public domain lands. This would place the law in much closer conformance with geological and technical reality.

There are, of course, variations to this alternative. The major one is the continuation of the present system under which acquired lands are distinguished from original public domain, depending upon the particular legislation under original public domain, depending upon the particular legislation under which they were acquired. This has led to considerable confusion and a multiplicity of variable practices and policies for public lands which are, in other terms, not at all distinguishable. The implications of this variation, the continuance of the present system of distinction between public domain and acquired land, is that the existing confusion in minerals exploration, acquisition, and production would be continued and probably heightened as more lands are acquired for public use under future legislation.

7. All Public Lands Administered by a Single Federal Agency

Under this alternative, all public lands would be administered by a single agency of the Department of the Interior. This would include those *public* lands now administered by the Department of Agriculture, but it would not include those *federal lands* administered by the Department of Defense, the General Services Administration, or the Atomic Energy Commission for specific nuclear testing. Under this alternative, prime responsibility for the public lands would be held within one exceutive department by one administrative agency. This agency would administer all public lands open to exploration and acquisition for mineral purposes.

The implications of this alternative would be felt primarily in the federal administration of the public land laws regarding mineral resources. The alternative would either eliminate the United States Forest Service as a separate agency of the Department of Agriculture and incorporate it within the Department of Interior, or withdraw all of those areas administered by the Forest Service from possible mineral exploration and acquisition and formally make forestry and grazing a specific activity of the federal government. The more logical of these two courses of action, of course, is to place the land areas now included within the National Forests within the jurisdiction of the Department of the Interior. Such a move would be likely to have numerous and varied implications and repercussions within the federal government. It would, however, result in considerable simplification and greater coherence in public land minerals policy and procedures, and it would also result in the fixing of primary responsibility for mineral activities within the national forests, thereby eliminating the dual responsibilities now shared by both the Bureau of Land Management and the Forest Service.

The impact of this alternative on state and local government would probably be nil. The impact on local and regional economies would probably also be slight, except as the consolidation of federal agencies might diminish federal employment in local areas now administered by the Forest Service. The direct effect on the national economy would also probably be relatively slight and would come through the consolidation of federal agencies and the resulting cost reductions to the federal taxpayer. At the local and regional levels, however, there could be a significant impact resulting from changes in federal agency policy towards competing uses of those areas now included within the National Forests. The alternative would probably result in a greater incentive toward the true multiple use of public land areas and the "highest and best" use of the public land.

The effects of this alternative upon the relationships between the mineral industries and the physical and social environment would probably be minimal. The same would be true for the relationships between mineral users of the public lands and nonmineral users of the public lands except in those areas where Forest Service administration has resulted in preferential treatment for certain types of nonmineral users. This alternative would probably result in a more appropriate balance between competing and complimentary uses of the public lands.

The essential impact of the alternative upon the mineral industries themselves would be to enhance the conduct of mineral exploration, development, and production operations on those portions of the public lands now controlled by the United States Forest Service. It would probably also provide a greater incentive to the small minerals producer in these areas and would remove the existing preference given to large mineral producers. It could also result in the elimination of the abuses occasioned by the excessive use of free-use permits on Forest Service land. The probable impact upon the mineral resources of the United States would be an increase in their availability. It would undoubtedly place the administration of the federal public land laws (as they pertain to mineral resource exploration, development, and production) in much closer conformity with geologic, technical, and economic reality.

The major variation of this alternative is to retain the existing distinction between lands administered by the Forest Service of the Department of Agriculture and those lands administered by the Bureau of Land Management in the Department of the Interior. The continuation of this arrangement would mean a continuation of the present distinction in mineral policy on those two portions of the public lands and probably would result in continued abuses of administrative authority by the Forest Service.

One problem that would probably arise at this point, particularly in view of the other alternatives already described, would result from a situation in which a significant mineral discovery is made on Forest Service land under an exploration franchise and is then followed by a request from the discoverer for the purchase of that land for mineral purposes. It could be said that, since the particular area desired is National Forest land, it should not be sold to a private interest. In the light of the primary purpose of a National Forest, however, if any land now in a National Forest area can be considered to have a higher value as a mineral-producing area, there is strong justification for advocating that it probably should be removed from the National Forest. This assumes that the value of its subsurface resources are significantly greater than the value of its surface resources. (See Chapter 14.) For those areas considered worthy of preservation as wilderness or primitive areas, it would undoubtedly be more consistent with physical reality and with the purpose of the delineation of those areas to place them within the administration of the National Park Service and remove them from status as *public lands*. This would make them essentially *federal lands*, and would declare the preservation of a wilderness or primitive areas as a specific federal activity. Such a procedure would require that serious consideration be given to the alternative uses of any given portion of land that is now in the public land category. The implications of this alternative and the variations of it are indeed far-reaching, and they are largely political in nature. The long-range economic aspects of the proper allocation of the limited land and other natural resources of the nation are also directly involved, however.

8. All Minerals to be Considered Alike

It has been implied in the alternatives to the existing public land system already described that there should be minimal distinctions between the various mineral commodities. Under this alternative feature, at least all nonfuel minerals would be considered the same, and no distinctions would be made between them or between any classes of them. This alternative could also be expanded to include the fuel minerals as well, and the most reasonable variation would include coal and oil shale, along with the nonfuel minerals. In other words, all *solid minerals* would be included in one minerals category.

The implications of this alternative for the federal adminstration of the public land laws with respect to mineral resources would be to simplify that administration and to diminish considerably the need for distinctions between specific mineral commodities and specific mineral deposits. Some of these existing distinctions are highly questionable, and their use is even more questionable. The impact of the alternative on state and local governments would probably be unnoticeable, except where revenues from lease payments and royalty payments for leaseable minerals are currently shared with those state and local governments. The alternative would do away with the distinctions between locateable minerals, leaseable minerals, and disposable minerals.

The economic effects of this alternative would be several. In the public sector, the cost of public land administration would be decreased through simplification of the necessary administration of the law. At the same time, revenues received from mineral leasing might be either decreased (if all minerals were considered not leaseable) or increased (if all minerals were considered to be leaseable). The impact on national, local, and regional governments, then, would primarily depend upon the other provisions of the public land laws regarding mineral resources.

The effects of this alternative on the relationships between the minerals industries and the physical and social environments would also depend upon other specific provisions of any public lands mineral system. This would also be true for the relationships between users of the public lands mineral resources and nonmineral users. For the mineral industries themselves, this alternative would result essentially in a simplification of exploration, development, and production procedures, depending, of course, upon the other specific provisions of public land mineral legislation. Whether or not it would provide an incentive to increased mineral production would depend upon how all minerals were treated under a single category, and not simply with the fact that all were considered alike. The same would be true of the relationships between the mineral resources themselves and the law.

Placing all solid minerals under a single category for equivalent consideration under the law brings that law into much closer conformance with geologic reality. If, however, other features of the public land mineral law then proceed to treat all of those minerals in an unrealistic manner, this advantage is lost. Probably the only distinction between the various mineral resources that is in conformance with geologic reality would be a distinction based upon the physical state of those minerals in place within the earth, either as solids or as fluids. In some respects, however, unconsolidated materials such as sand and gravel could be considered fluid, and this would be a reasonable distinction in many respects. Nevertheless, with the development of solution mining techniques, even such a distinction as that between fluids and solids could cause some problems in the administration of the public land mineral laws.

Many variations to this alternative exist. In fact, there are at least as many variations as there are minerals. The most extreme variation would be to consider every mineral as distinct from every other mineral. This extreme may appear ridiculous in the light of geologic reality and the similar characteristics of many deposits of dissimilar minerals. Nevertheless, an approach has been made to such complete distinction in the existing system by the treatment of different minerals in different ways under separate pieces of public land legislation. The implication of these sometimes artifical distinctions between similar commodities is to generate considerable confusion in the search for and utilization of mineral resources on the public lands, particularly where two minerals of different categories are intermingled in the same deposit.

The other extreme is to consider all minerals, both fuel and nonfuel, as well as other subsurface resources, including geothermal steam and water, in the same category. The particular characteristics of certain subsurface resources such as water, however, make this unrealistic politically, economically, technically, and geologically. There are, nevertheless, significant justifications for the treatment of petroleum, natural gas, helium, and otherwise fluid subsurface resources as similar enough to those subsurface commodities which exist in a solid state. Such an all-inclusive consideration of all minerals, to be effective or meaningful under the public land laws, however, would have to be carried through to other types of legislation, and in particular to the tax laws.

9. Public Land Information Requirements

As one feature of any alternative system of public land mineral law, the federal government could be required to make accurate, basic geographic and geological information available to potential users of mineral resources on the public lands. Under one variation of this alternative, the federal government would be required, through the United States Geological Survey, to provide accurate, topographic, and basic surface geology maps of all land in the public domain of the United States. Copies of these maps would be available upon request solely for the cost of printing and handling. In addition to these basic maps, other maps containing basic geophysical data, such as magnetometer and gravimetric readings, would also be made available for large areas. A program for the provision of basic, large-area, background geochemical data would also be instituted through the United States Geological Survey. This alternative would make the United States Geological Survey a provider of basic mineral resource and surface resource information.

In many respects, this alternative is simply a statement of the functions of the Geological Survey as they exist today. In other respects, however, it is a restriction of certain of the Survey's operations and yet also an expansion of certain activities. The effects of these possible restrictions and expansions would be several. There would be an initial direct impact upon the federal government itself by this alternative feature making the federal government a provider of basic natural resource information. The requirement that the federal government provide basic background information of a geophysical and geochemical nature for large areas of the public lands would, in effect, be an expansion of existing responsibilities. The direct impact of this requirement would be to expand federal activities on the public lands. On the other hand, in certain respects, this alternative (along with other features of the system being evaluated) would remove certain functions from the federal government, including those involved directly in the search for specific minerals and in the classification of lands as *mineral* or *nonmineral.* The removal of such functions from the Geological Survey would curtail government operations to the extent of those functions. The net effect, however, probably would be an expansion of the activities and personnel of the Geological Survey.

The major impact of this alternative on state and local governments would be essentially indirect. Nevertheless, the definition of activities carried on by the United States Geological Survey with regard to the public lands would have, in many instances, a direct relationship to the activities carried on by state geological and mineral resource departments. Whether or not the activities of such state departments were coordinated with activities at the federal level would depend upon the various state governments involved. The portion of the alternative that would require the completion of the Public Lands Survey would have its greatest direct impact upon local governments in those unsurveyed areas.

The primary effects of this alternative upon the economic environment would be favorable. The direct provision of additional information regarding the surface and subsurface characteristics of the public lands of the United States should stimulate (all other things being equal) activity upon those public lands. This would have an impact on national, regional, state, and local economies. The extent of the stimulus to local and state economies provided by increased activity on the public lands would depend upon the nature of existing information regarding the public land in those states and localities. The greatest impact of the information requirement would be in lands where information now is relatively sparse, and it would be leaset in areas where abundant information is already available. Likewise, it would be impossible to provide all of the information on all of the public lands at the same time. Thus, the initial impact of the requirement of this alternative would be felt first in those areas where such information programs were first instituted.

The impact of the information requirement of this alternative on the relationships of the mineral industries and the physical and social environment within which they operate on the public lands would be generally beneficial. The provision of accurate basic data, particularly topographic and surface geology information, should enable the presentation of an accurate and complete picture of the relationship between the mineral resources and other resources on the public lands. This would also be true of the relationships between the users of mineral resources on the pbulic lands and other users, both existing and potential, of those same lands.

The impact of this alternative on the mineral industries themselves would be to provide a stimulus to additional search for mineral resources and the more effective utilization of known mineral resources on the public lands, particularly in areas where basic geographic and geologic data are not now available. This would be particularly true of areas that have not yet been included within the Public Land Survey. With respect to the mineral resources themselves, the requirement would, in effect, make additional resources available to proper and effective utilization by the mineral industries. The requirement would certainly bring the law and the administrative activities of the federal government into much closer conformance with geologic and other physical reality.

There are basically two variations of this information alternative. One would be to severely limit the amount of information about the public lands to be supplied to the general public by the federal government or its administering agency for the public lands. The effects of this variation would undoubtedly be adverse, both as to the development of the mineral resources on the public lands and also for the effective administration of those lands. Adequate and complete basic information is a necessary adjunct to the effective administration of any federal property. The other variation of the alternative would involve the Geological Survey or other federal agencies in the provision of information other than that resulting from fundamental or basic research activities. To a certain extent, this has already been done in certain applied research activities of the Geological Survey and the Bureau of Mines, most specifically in their programs involving specific mineral commodities. In effect, under this variation of the alternative,they would be engaged in active minerals reconnaissance and detailed exploration with the information to be made immediately available to the general public. This has not been a successful function of the United States government in recent decades, its failure to find new uranium deposits being the most notorious example.

This alternative would put the federal government (through these agencies) in direct competition with private firms and individuals engaged in minerals exploration. It would also tend to have an effect on the federal government itself, in channelling resources, time, and personnel to specific areas of the United States where favorable indications for the presence of selected minerals had been or might be found. This could lead to a general neglect of other areas of the public land. This has, in fact, already happened, as evidenced by the relatively large extent of public land areas in the Western United States that still have not been made a part of the Public Lands Survey. There have also been adverse economic effects resulting from the practice of this variation in the past. In certain areas, the publication of geologic, geophysical, and geochemical data with respect to the occurrence of specific valuable minerals in specific locations has resulted in inflated land prices and made effective utilization of those minerals in those areas difficult for private interests. This adverse consequence of detailed minerals exploration activity by the federal government could be expected to continue and perhaps become even more severe.

10. Centralized Recording of Public Land Status Information

Under this alternative, the federal government would be required to keep, in at least one central place in each state of the United States, an accurate appraisal of the current tenure status of all public land, and this information would be available to the general public without charge. This alternative would, in effect, continue the present program operated by the Bureau of Land Management in its various state offices, and improve it where necessary. The alternative would also curtail the need for the filing and maintenance of records regarding mineral land status in the county recorders' offices of each county in the public land states.

The implications of this alternative feature for the federal government would be directed towards the administration of public lands by the Bureau of Land Management. It would result in a consistency of operation within the Bureau of Land Management state offices and should result in an improvement of recordkeeping and land status information operations. The initial effect would be an expansion of activities in the state offices of the Bureau of Land Management to the extent necessary to modernize existing records and improve the availability of information services to the general public. The most direct impact upon local governments would be just the reverse, with the major effect being felt at the county government level where the need for the recording and filing of mining claims would be eliminated. For some counties in the West, this would result in a major decrease in responsibilities regarding the provision of information about the public land. The direct impact on state government would be essentially neutral.

The effects on the public sector of the economy of this centralized records alternative would probably be offsetting. Increased federal expenditures would be required in the various state capitals or other centralized locations within each state resulting from an expansion of Bureau of Land Management activities. These would be countered, however, by what would probably be complementary reductions in the expenditures necessary by county governments in the maintenance of public land mineral records. The impact on the private economy would be essentially a reduction of costs involved in mineral land acquisition by private interests in that the cost of clearing title and obtaining information about the public lands regarding their mineral resources and tenure status would be reduced. For some areas, and for some firms, this cost reduction would be considerable.

The effects of this centralized records alternative on the relationships between the mineral resources of the public lands and the physical and social environment probably would be neutral. The same can be said for the effects of the alternative on the relationships between nonmineral users of the land and mineral resource users. The feature, however, would make identification of mineral and nonmineral resource users much easier.

The major impact of this alternative on the mineral industries themselves would be to reduce the cost of mineral land acquisition and, in particular, the cost of determining the status of public lands with respect to mineral resources. It should also, by making more complete information more readily available in a centralized and accessible location, provide an incentive to more complete competition for the public lands among existing and potential mineral resource users. As far as the impact of the alternative on the mineral resources themselves is concerned, this alternative should make a greater amount of mineral resources on the public lands more readily available to both existing and potential resource users.

One of the possible variations to this alternative feature (and which has been practiced in the past) is the continuing maintenance of information regarding public land status with regard to mineral claims available only at the county level. The effects of this practice have been several. One of these has been to remove from the federal agency directly responsible for the administration of the public lands the information about those public lands that it vitally needs for its administration to be effective. The other impact has been on local governments in making additional requirements upon their already overtaxed facilities in providing and maintaining information about federal lands. Because every county government in the United States is operated in a somewhat different manner, the maintenance of records by the counties has resulted in a wide variation in the type and relative completeness of public lands mineral status records. This has tended to make the search for and the acquisition of mineral resources on the public lands of the United States more difficult for private interests desirous of developing the mineral resources of the public lands.

The other extreme variation of this alternative is to have all public land information available and maintained only at the national headquarters of the Bureau of Land Management in Wasington, D.C., or, at best, at a regional headquarters somewhere in the public lands states of the West. The implications of this variation should be obvious. It would, through the extreme centralization of information, restrict the availability of that information to the general public and to existing and potential mineral resource users. This increase in the difficutly of access to necessary information would have a detrimental effect upon the utilization of mineral resources on the public lands of the United States.

11. Other Alternatives

There are numerous other issues of public lands mineral policy that might be treated by specific alternative features of public land law systems. Some of these are substantial, while others are relatively minor. Some are concerned specifically with the nonfuel minerals, while others are pertinent to all natural resources. One of the more important of these concerns the disposition of land that has been disturbed by mining operations after those operations have ceased. (See Chapters 13 and 14.) There seem to be three possible alternatives for dealing with this issue. The first would involve doing nothing about post-production utilization or reclamation of mined-out land. This seems to be the alternative least desired by most, and the alternative with the greatest potential for adverse consequences upon the government, the economy, the mineral industries, and the resources themselves.

Another alternative would involve the federal government directly in the reclamation of mined-out land. This could undoubtedly be costly, could result in the destruction of new values created by the rearrangement of the surface by mining, and could also create an added tax burden disproportionate to the benefits received. A more logical alternative would have the government provide economic incentives to private landholders or mineral leaseholders for the upgrading of land disturbed by mining operations. This could also result in public burdens disproportionate to public benefits, however.

Probably the most logical alternative would be to allow land that has been mined to remain in private hands so that the forces of the market may dictate the uses to which the surface will be put after mining has ceased. This is essentially a part of the alternative for mineral land acquisition discussed in Section 5. Relevant background data are provided in Chapters 13 and 14.

Another major issue that pervades many of the alternatives already outlined concerns the amount of discretionary authority that the Executive Branch, and in particular the Department of the Interior, may be allowed to have in public lands management. This likewise is a problem that is not at all confined to the nonfuel minerals, but which is appropriate to all natural resources, and in fact, to all aspects of public land policy. It also is an issue of far greater philosophical import than most of the issues treated herein, for the actual impact of any of the alternatives that could be devised would depend largely upon the character of the man occupying the position of Secretary of the Interior. At one extreme, a system could be developed that would be so detailed and so structured that the Department of the Interior would have little or no discretionary authority. Such a system would have all of the disadvantages of any highly rigid and legalistic system. On the other hand, a system could be established that would give virtually unlimited discretionary authority to the Secretary of the Interior, who might himself then delegate such authority or retain it through a departmental system of detailed rules and regulations. Between these two extremes lie an almost infinite number of possible compromises. Like most other features of public land law and policy, it is most probable that one of these compromises is the best alternative.

NONFUEL MINERAL RESOURCES
AND THE
PUBLIC LANDS

APPENDIX

Prepared for
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APPENDIX A

THE WORKING HYPOTHESES USED IN THE CONDUCT OF THE RESEARCH

(Relevant to Chapter 1)

APPENDIX A

THE WORKING HYPOTHESES

In examining the changes that were hypothesized to have occurred in the nation's nonfuel mineral resources since the period just prior to the passage of the country's basic mineral legislation, a number of specific questions were framed. It was asked,

> *Have there been discernible trends in the major characteristics including average grade, size, degree of concealment, and major structural and petrological features of selected nonfuel mineral deposits that have been brought into production since the 1860's? Can any trends since 1947 be projected to 1985?*

Closely related to this is the question,

> *Have the relative proportions of metals produced as co- or by-products from complex deposits and from simple deposits in which they are the principal product changed in a discernible trend which may be projected to 1985?*

The need for information regarding the location of the nation's nonfuel mineral resources prompted two questions. The first asked,

> *Have there been discernible geographic shifts in the production of nonfuel minerals and will there probably be further shifts before 1985?*

The second was aimed more at the reasons for the particular location of nonfuel mineral resources, and asked,

> *Does that part of the contiguous continental United States west of the 105th Meridian have geological characteristics significantly different from the rest of the nation, including some mineral resources that, although presently not considered valuable, could become commercially productive by 1985?*

The actual size as well as the location of the known minerals resources of the United States was also of concern, and so a query designed to produce just such information was formulated as,

> *For those minerals specified by the Commission's requirements, have there been varying estimates of reserves made since 1947 which for various reasons have not been substantiated by subsequent production figures?*

Finally, and of more specific relevance to the public lands, it was asked,

> *Have there been measurable changes since 1947 in the number of claims patented, in the number of permits and leases issued, and in the value of minerals produced on public lands, and have these changes been related to certain identifiable characteristics of the nonfuel mineral industries and public land policy?*

Similarly, in order to test the second basic hypothesis regarding nonfuel mineral exploration, development, and production, a number of specific questions were devised. Each of these was related to specific facets of mineral resource utilization. The first asked,

> *Have there been significant trends in the organization, methods, and techniques used in nonfuel minerals exploration and have these been influenced by varying factors?*

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while the second queried,

> *Are there significant differences in the methods and techniques of exploration used for different major groups of nonfuel minerals?*

and the third was framed as,

> *Do different phases of the mineral exploration process have different objectives and do they use different methods and techniques?*

A fourth question regarding exploration methods and techniques inquired,

> *Do different methods, techniques, and phases of mineral exploration normally involve different time spans, costs, and land areas?*

The results of minerals exploration were likewise made the object of several questions. The first was,

> *Are the probabilities of success in exploration for nonfuel minerals determinable, and do they vary measurably by type of resource?*

The second also involved some of the means by which minerals exploration is conducted, asking,

> *Are there several different types of entities engaged in exploration for nonfuel minerals in the United States, and do they have different degrees of relative success in performing such exploration?*

The minerals exploration as a result itself was the object of a third query that asked,

> *Have there been measurable trends in the allocation of nonfuel minerals exploration efforts between foreign and domestic areas, between publicly and privately held lands in the United States and between established mining districts and non-productive areas?*

In an attempt to relate minerals exploration to the periods during which the principal legislation governing the search for minerals on the public lands was enacted, the following question was framed:

> *Have the relevant characteristics of, and the organization, methods, and techniques involved in exploration for nonfuel minerals changed since 1860 and again since the early 1900's?*

In order to also relate minerals exploration to the period in which prospective legislation would be in force it was further asked,

> *Are the relevant characteristics of, and the organization, methods, and techniques that will be in use in nonfuel mineral exploration by 1985 predictable?*

In addition to those questions established with specific reference to nonfuel minerals exploration, another series was devised relating to the development of known mineral deposits and the actual production of mineral commodities. A number of these questions were general in nature but most were related directly to the relationships between mineral resource utilization and public land policy. Among the more general questions was,

> *Have there been measurable trends in the major technical and economic characteristics of the development and production phases of the nonfuel minerals industries, and have these been influenced by identifiable factors?*

With more specific reference to the mining phase of production was,

> *Have there been measurable and significant changes in the technical and economic characteristics of nonfuel mining methods?*

Even more specific was the question,

> *Have there been measurable changes in the utilization (intake, consumption, and discharge) of water by the nonfuel mineral industries?*

In order to aid in developing data about specific aspects of minerals production and its actual and potential relationships with the public lands and public land policy, two further questions were set forth. The first was,

> *Have there been changes in the relationships among technology, scale, investment, time, reserves, and prices involved in the development and extraction of nonfuel mineral resources?*

The second asked,

> *Have there been measurable changes in the number, size, land area occupied, and concentrations of properties actively producing nonfuel minerals in the United States?*

Because of certain specified informational needs defined by the staff of the Public Land Law Review Commission, several additional questions were designed. These concerned certain detailed aspects of minerals production related directly to definite issues in public land policy. The first asked,

> *Have there been measurable changes in the importance of the "small" miner in certain Western States, and specifically in Colorado, Idaho, and New Mexico?*

The other inquired,

> *Has there been an increase in the propensity to incorporate metal reduction or other advanced processing facilities (heretofore classified as manufacturing plants) into the mining and beneficiation complex?*

In order to relate the development of mineral deposits and the production of mineral commodities to the time periods during which the principal laws governing the utilization of the mineral resources of the public lands were enacted, the following question was framed:

> *Have the relevant characteristics of nonfuel mineral development and production changed since 1860 and again since the early 1900's?*

To further relate mineral development and production to the time period during which prospective legislation would be in force, it was also asked,

> *Does the projection of existing trends make changes in the major economic and technical characteristics of nonfuel mineral development and extraction predictable?*

The requirements of the Commission made it necessary to frame an additional series of questions about what is probably the most important of the industrial minerals, limestone. These involved primarily the production of limestone and limestone products but were also concerned with limestone as a mineral resource. The first of this series involved both, asking,

> *Do the chemical and physical characteristics of limestone and other industrial minerals determine their saleability?*

The second also involved other minerals as well as limestone. It inquired,

> *Do the major aspects of marketing limestone and similar industrial minerals vary significantly from those found in marketing certain other non-metallic minerals and the metals or their ores?*

The third similarly involved a comparison between limestone and other mineral commodities in asking,

> *Do the size of productive facilities normally used, and the time and money involved, in the development of limestone and similar industrial minerals deposits vary from certain other non-metallic minerals and from the metals or their ores?*

The fourth concerned only limestone and queried,

> *In the 11 Western States are there certain proportions of total available limestone deposits that are suitable for different uses?*

In order to describe the position of the nonfuel minerals in the economic environment, several specific hypotheses were framed as questions. These each concerned a particular aspect of the relative role of the mineral industries in the economy as a whole. The first inquired,

> *Has the relative contribution of the nonfuel mineral industries to national income changed, as have those of other major economic sectors?*

The second was similar and asked,

> *Has the relative importance to the national economy of employment and wages in the nonfuel mineral industries changed as have employment and wages in other major industries?*

Three other questions were made more directly relevant to the public land states. The first of these asked,

> *Has the relative importance of the 11 Western States region in the total employment and income of the nation changed?*

The second of these closely paralleled the questions regarding the place of minerals in the national economy, but asked,

> *Has the relative contribution of the nonfuel mineral industries to state economic income in each of the 11 Western States changed as have the contributions of other major economic activities in each of those states?*

Similarly, the next question was,

> *Has the relative importance to the economies of each of the 11 Western States of employment and wages and salaries in the nonfuel mineral industries changed as have employment and wages in other major economic activities in each of those states?*

A more specific question concerned the role of the mineral industries in the public sector. Because of expected limitations imposed by the availability (or rather the inavailability) of data, it was made to read,

> *In 1966-67 in Arizona, Colorado, New Mexico, and Utah, was the net public revenue derived from the nonfuel mineral industries different from that derived from other major economic activities within each state?*

Other aspects of the place of minerals in the economic environment were also to be examined and this led to questions such as,

> *In recent years, has the economic development of the Pacific Basin had a measurable effect upon the nonfuel mineral industries of the 11 Western States?*

as well as to one more closely related to the avowed original intent of the earlier mining legislation passed in the 1870's. This was,

> *Has the development of import replacing industries in the 11 Western States had a measurable impact upon the nonfuel mineral industries in those states and particularly upon the industrial minerals industries?*

The intended results of that early legislation also became involved in the question,

> *Since 1860, and particularly since 1947, have there been identifiable patterns, both geographic and otherwise, in the development of nonfuel mineral resources in the 11 Western States?*

Finally, the need for reasonable assumptions about the future of the nonfuel mineral industries led to asking,

> *Will changes in demand for nonfuel minerals by 1985 be likely to have varying effects upon the nonfuel mineral industries of the 11 Western States?*

The development of data regarding the effects of the mineral industries upon the physical and social environment required the formulation of several complex questions which were actually composed of a series of more specific questions. The first of these complex questions was stated thus:

> *Can the nature and magnitude of the effects of the nonfuel mineral industries upon both their human and physical environments both on-site and off-site be measured in monetary or other terms?*

The second of this group was far more complex and dealt with various aspects of the environment in asking,

> *Can the nature and extent of the various effects of the nonfuel mineral industries upon water resources, atmospheric conditions (including noise levels), land and soil resources, biological resources, and aesthetics be measured in monetary as well as other terms?*

The third question attempted to relate the environmental relationships to the public land states. It inquired,

> *Are the effects of the nonfuel mineral industries upon the physical and social environment in the 11 Western States similar to the effects produced by those industries in other regions of the country?*

Three other questions were devised to guide the search for information about potential or expected changes in the relationships between the mineral industries and the physical and social environments. The first of these concerned induced changes and queried,

> *Are there methods for reducing or eliminating the adverse effects upon the environment of nonfuel mineral industry activity and can the costs of these methods be determined?*

The second was also concerned with induced changes, but in a more negative way. It asked,

> *Do unsolved technical problems exist in the reduction or elimination of the adverse effects upon the environment of nonfuel mineral industry activities?*

The third involved potential future changes in environmental relationships, those that will be likely to exist during the period in which prospective public land policy might be effective. It was worded to determine,

> *Are there anticipated changes in the technology of mineral exploration, development, and production that may have measurable impacts on the effects of the nonfuel mineral industries upon the environment?*

One particularly complex question was devised to guide the study in examining the relation of mineral resource users to other users of the other resources of the public lands. This question was framed thus:

> *Have the exploration for and the development and production of nonfuel minerals in the 11 Western States had measurable effects, either direct or indirect, upon the utilization of other natural resources in the region, and has this been particularly true of recreation resources in Colorado, Nevada, and Arizona, and of timber resources in Oregon and Arizona?*

The complexity of the question was intended only to assure completeness in the answer.

In order to assure coverage in the study of problem situations known to have arisen as a result of mineral resource utilization on the public lands, several more specific questions were formulated. Probably the most specific of these was,

> *Have the present legal requirements for the marking, recording, and retention of unpatented mining claims had measurable effects upon other users of the public lands, and if so, can the magnitude of these effects be expressed in monetary terms?*

The others were somewhat less closely defined. Two of these were concerned with the effects of other users on the mineral industry. They asked,

> *Have other uses of the public lands had measurable effects upon the nonfuel mineral industries in the 11 Western States, and particularly in California, Washington, and Arizona? Has the withdrawal of lands from possible mineral industry use also had such effects?*

The three final questions in the environmental relationships group were aimed at providing factual data for consideration of the magnitude of the multiple or conflicting use problem. The first of these was worded,

> *Can the total land area within the state of Arizona (in 1966-67) be classified according to use, and can relative acreages be determined for the following uses: mining, transportation facilities, timber production, cultivated agriculture, developed recreation, public utilities, urban uses, and burned-over areas?*

A related question injected economic variables and historical changes in asking,

> *Since the late 1800's has the gross value per acre of production of nonfuel minerals, forest products, and livestock changed measurably in Arizona?*

The third question concerned more recent activity only and directly involved mineral resource use with the use of public land surface. It inquired,

> *In recent years, has the acreage used for mining purposes in Arizona varied with the size of mining operation in terms of productive capacity?*

In each of these three questions, Arizona was used for two reasons. First, data would thus be more readily available to the study group than for any other state. Second, the variety of land forms and land use in Arizona reproduces virtually every type found in the other Western States.

With respect to the relationships of the nonfuel mineral industries to the institutional environment, several aspects of that environment were considered. These included the legal, administrative, and political facets of the institutional framework within which the mineral industries must operate. The first set of questions developed involved the operation of the mineral industries on private lands, within the non-public legal environment. The first question in this set was rather all-inclusive in asking,

> *Do the numerous terms and conditions of mineral tenure on non-public lands vary according to the nature of the original title, method of title transfer, size of area involved, duration of tenure, means of payment, nature of performance requirements, retention of interests by former owners, extent of payments in lieu of work, and requirements concerning environmental effects?*

The subsequent questions in this group were also devised to elicit information about differences within the legal environment itself. The second question was thus worded to read,

> *Do provisions governing nonfuel mineral exploration, development, and production on non-public lands vary according to the state in which the land is located and the type of mineral involved?*

The third inquired, in similar fashion,

> *Do provisions containing discretionary rights to change the terms and conditions of mineral tenure agreements on non-public lands regarding rentals, royalties, or methods of operation during the time of agreement vary according to the state in which located and the type of mineral involved?*

Likewise, as part of the institutional environment section, two questions were formulated to assist in obtaining data in those instances where public and private land systems overlap, i.e., where surface rights have been transferred to private ownership but with mineral rights reserved to the federal government. The first of these two questions inquired, in a complex manner,

> *Has the existence of reserved mineral rights involving public lands had varying effects on the holders of the surface rights, the nonfuel mineral industries, and various levels of government, and have these effects varied according to the type of use of the surface (i.e., urban, intensive agriculture, grazing, timber, or recreation), and can they be measured in terms of appraised value of the land, the effects on surface resources by mining activity, and the costs of evaluating the mineral character of the land?*

With the future of considerably more concern than even the present in this study, a further question was framed to determine,

> *Can the public land areas with reserved mineral rights that are most likely to become targets for nonfuel minerals exploration and development before 1975 be determined and measured and their land values estimated?*

These overlapping areas of concern led directly to the development of a series of questions regarding the actual effects of the existing system of public land policy with respect to nonfuel mineral resources and their utilization. The first of this series asked,

> *Have the provisions of existing public land law and policy regarding discovery requirements and assessment work on mineral claims created physical and economic problems in the light of present trends in nonfuel mineral exploration?*

The second question also involved a situation known to be causing a problem, at least in some quarters. It was,

> *Are the provisions of existing public land law and policy concerning the size of individual mining claims and leases consistent with existing trends in the size and shape of mineral deposits being exploited?*

Several more also questioned the apparent lack of agreement between the existing system and technical and economic reality. One of these inquired,

> *Are the existing provisions of public land law and regulation concerning the duration of tenure of mineral leases consistent with existing trends in the length of time required to bring mineral deposits into production and amortize the capital investment required?*

Another also questioned the existing durations of mineral tenure on public lands, reading,

> *Are the existing provisions of public land law and policy regarding the length and conditions of mineral tenure consistent with current trends in the costs of mineral resource development and the sources of funds available to meet those costs?*

Other questions were designed to permit examination of various other hypothesized inconsistencies between the law and reality. One of these read,

> *Are the existing provisions of public land law and policy concerned with the protection of land and vegetation from despoilment consistent with current developments in the processes of mineral exploration and utilization?*

while another asked,

> *Are the existing provisions of public land law and policy which govern the amount and terms of payment for mineral lands consistent with the actual and potential market values of the mineral resource and the cost of extracting and selling that resource?*

Still another inquired,

> *Are the existing provisions of public land law and policy governing the closing of or restricting the availability of lands for mineral industry activity consistent with current trends in the geographic location of nonfuel mineral resources and industry activity and with changing national demand for nonfuel minerals as well as with the magnitude of the areas actually used for such activity and the values produced from those areas?*

Hypothesized inconsistencies within the established legal and administrative machinery used to carry out public land policy were also made the subject of specific questions. One of these queried,

> *Are the existing provisions of public land law and policy concerning the activities of the federal government in gathering, using, and disseminating information about nonfuel minerals on public lands consistent with the costs incurred by and the revenues received from these activities as well as with the uses made of the information?*

while another was designed to ascertain,

> *Are the existing provisions of public land law and policy which govern the acquisition of mineral lands held under the jurisdiction of different government agencies consistent with the technical and economic requirements of land acquisition to mineral producers?*

The final question in this set regarding the existing public land system was concerned with the problems apparently created in some instances by the conflict between law and reality. It asked,

> *Have the existing provisions of public land law and policy concerning the rates of recovery required from nonfuel mineral deposits caused physical and economic problems in the light of current trends in mining technology and mineral markets?*

The last group of specific questions developed was designed to aid in the analysis of proposed alternatives to the existing system of public land law and policy with respect to the nonfuel mineral resources and their use. The first and perhaps most obvious of these was,

> *Are there weaknesses in existing public land law and policy which may be removed or alleviated by one or more modifications in law and/or policy?*

The second question followed from the first in going on to ask,

> *Are there certain requirements, already established technically, economically, or legally, which make certain features of any modification in public land law or policy necessary?*

Once the answers to such questions as these could be obtained, they would establish the basic framework within which the study's two last questions could be asked. Then it could be determined,

> *Would any modification of existing public land law or policy involve an operating procedure which could be described prior to enactment?*

It could also then be asked in evaluating any proposed alternative,

> *Would any modification of existing land law or policy have one or more determinable impacts, either direct or indirect, on: (1) the nonfuel mineral industries; (2) the federal and state governments; and (3) the economic, physical, and social environment within which the nonfuel mineral industries operate?*

The answers to this final question would, of course, be dependent upon the answers to all those preceding.

APPENDIX B

THE ECONOMIC GEOLOGY
OF THE
UNITED STATES

(Data relevant to Chapters 2, 3, 4, and 5)

Table B-1

LIST OF MINERALOGICAL ABBREVIATIONS USED IN FIGURES 13 THROUGH 16 IN CHAPTER 2

(Excludes standard chemical symbols)

hm = hematite

Lm = limonite

sid = siderite

Mg = magnetite

Py = pyrite

po = pyrrhotite

ap = apatite

cp = chalcopyrite

bn = bornite

cc = chalcocite

cu = native copper

pn = pentlandite

cub = cuprite

td = tetrahedrite

tn = tenantite

en = enargite

an = anglesite

sl = sphalerite

gn = galena

cy = chrysocolla

Table B-2

MINERALOGICAL TRAITS OF PRINCIPAL KNOWN METALLIC MINERAL DEPOSITS IN THE UNITED STATES

	Dominant Minerals in:		
Metal	1860	1947	1968
Iron	high grade iron oxide, > 60% iron (hematite, magnetite)	high grade iron oxide, > 60% iron (hematite, magnetite)	low grade iron oxides (taconite <40% iron)
Copper	high grade oxide and sulfide	low grade oxide and sulfide	low grade oxide and sulfide
Nickel	not mined domestically	not mined domestically	silicates
Molybdenum	not mined domestically	high and low grade sulfide	low grade sulfide
Lead	carbonate sulfide, oxide	sulfide	sulfide
Zinc	sulfide and oxide	sulfide	sulfide
Gold	native metal	native metal, sulfides, arsenides, and tellurides	native metal, sulfides, and arsenides
Silver	native metal, chloride and sulfide	native metal, chloride and sulfide	sulfide
Mercury	sulfide	sulfide	sulfide
Uranium	not mined domestically	vanadates	oxide and silicates

Source of Data: E. Wisser and Associates

Table B-3

GEOLOGIC STRUCTURES OF PRINCIPAL KNOWN METALLIC MINERAL DEPOSITS IN THE UNITED STATES

	Type of Structure Commonly Mined in:		
Metal	1860	1947	1968
Iron	sedimentary beds and massive replacements	same	same
Copper	vein and massive replacements	disseminated	disseminated
Nickel	not mined domestically	same	laterite (bedded) and disseminated
Molybdenum	not mined domestically	disseminated and vein	disseminated
Lead	massive replacement and veins	same	same
Zinc	veins and massive replacement	same	same
Gold	placer, vein, and replacement	placer, vein, and replacement	replacement, vein, and disseminated
Silver	vein and replacement	same	same
Mercury	vein and replacement	same	vein, replacement and disseminated
Uranium	not mined domestically	vein and disseminated in sedimentary formations	bedded and disseminated

Source of Data: E. Wisser and Associates

Table B-4

APPROXIMATE AVERAGE SIZE OF INDIVIDUAL, PRODUCING MINERAL DEPOSITS IN THE UNITED STATES

(by Linear dimensions)

	Typical Magnitude of Orebody Dimensions (in feet)		
Metal	1860	1947	1967
Iron	1,000's x 100's x 10's	1,000's x 1,000's x 100's	1,000's x 1,000's x 100's
Copper (except Michigan)	100's x 10's x <10	1,000's x 1,000's x 100's	1,000's x 1,000's x 100's
Nickel	none	none	1,000's x 1,000's x 100's
Molybdenum	none	1,000's x 1,000's x 100's	1,000's x 1,000's x 100's
Lead	100's x 10's x <10	100's x 100's x 10's	1,000's x 100's x 10's
Zinc	100's x 10's x <10	100's x 100's x 10's	1,000's x 100's x 10's
Gold	100's x 10's x <10	100's x 100's x 10's	1,000's x 100's x 10's
Silver	100's x 10's x <10	100's x 100's x 10's	100's x 100's x 10's
Mercury	100's x 10's x 10's	100's x 10's x 10's	10's x 100's x 10's
Uranium	none	10's x 10's x <10	100's x 100's x 10's

Source: E. Wisser & Associates

Table B-5

APPROXIMATE AVERAGE SIZE OF INDIVIDUAL, PRODUCING MINERAL DEPOSITS IN THE UNITED STATES
(by tonnage)

Metal	Average Size of Known Orebody (in tons) 1860	1947	1967
Iron	< 1 million	<100 million	>100 million
Copper (except Michigan)	< 100,000	<100 million	>100 million
Nickel	none	none	>75 million
Molybdenum	none	<50 million	>50 million
Lead	10,000 ±	10,000 - 50,000	100,000
Zinc	1,000 - 5,000	10,000 - 50,000	100,000
Gold	<5,000	10,000+	100,000
Silver	<5,000	10,000 ±	10,000 - 100,000
Mercury	<5,000	<5,000	75,000
Uranium	none	<5,000	50,000

Source: E. Wisser & Associates

Table B-6

START OF PRODUCTION IN WESTERN NON FERROUS METAL MINING DISTRICTS

	District	Date Production Started	Principal Metals Recovered
1.	California gold placers	1848	Gold
2.	New Almaden, California	1850	Mercury
3.	Weaverville, California	1852	Gold (placers)
4.	Heintzelmann, Arizona	1856	Silver
5.	Mowry, Arizona	1856	Silver-lead
6.	New Idria, California	1858	Mercury
7.	Gilpin, Clear Creek Counties, Colorado	1859	Gold, silver
8.	Alma, Colorado	1860	Gold
9.	Star Peak, Nevada	1860	Silver, gold
10.	Taylorsville, California	1860	Gold
11.	Aurora, Nevada	1861	Gold, silver
12.	Knoxville, California	1862	Mercury
13.	Bannack, Montana	1862	Gold (placers)
14.	Virginia City, Montana	1863	Gold (placers)
15.	Candelaria, Nevada	1863	Silver
16.	Boise Basin, Idaho	1863	Gold (placers)
17.	Silver City, Idaho	1864	Silver, gold
18.	Vulture, Arizona	1865	Gold
19.	Grass Valley, California	1865	Gold
20.	Mother Lode, California	1865	Gold
21.	Comstock, Nevada	1865	Silver,gold
22.	Silver Bell, Arizona	1865	Copper
23.	Austin, Nevada	1865	Silver
24.	Sierra Nevada, California Foothill copper belt	1861	Copper
25.	Blue Mountains, Oregon	1865	Gold
26.	Helena, Montana	1866	Gold (placers)
27.	White Pine, Nevada	1869	Silver-lead
28.	Eureka, Nevada	1869	Silver-lead (zinc)
29.	Contact, Nevada	1869	Copper, lead
30.	Cortez, Nevada	1869	Silver-lead, with copper, (zinc)
31.	Cottonwood, Utah	1870	Silver-lead (zinc)
32.	Rosita, Colorado	1870	Silver-lead
33.	Philipsburg, Montana	1870	Gold, silver (manganese)
34.	Ophir, Utah	1870	Silver-lead
35.	Tuscarora, Nevada	1870	Silver, gold
36.	Belmont, Nevada	1866	Silver, gold, lead, copper
37.	Buena Vista, Nevada	1868	Silver, gold
38.	Gold Hill, Utah	1870	Copper, gold
39.	Radersburg, Montana	1866	Gold
40.	Pony, Montana	1870	Gold

Table B-6 (continued)

	District	Date Production Started	Principal Metals Recovered
41.	Pioche, Nevada	1871	Silver-lead (zinc)
42.	Park City, Utah	1872	Silver-lead (zinc)
43.	Chloride, Arizona	1872	Silver
44.	Great Western, California	1873	Mercury
45.	Telluride, Colorado	1873	Silver, gold, base metals
46.	Sulfur Bank, California	1874	Mercury
47.	Darwin, California	1874	Silver-lead (zinc)
48.	Oat Hill, California	1875	Mercury
49.	Mt. Jackson, California	1875	Mercury
50.	Superior, Arizona	1875	Silver
51.	Butte, Montana	1875	Copper, gold, silver
52.	Lake City, Colorado	1874	Silver
53.	Cornucopia, Nevada	1875	Gold, silver
54.	Mt. City, Nevada	1871	Copper, gold, silver, lead, (zinc)
55.	Mineral Hill, Nevada	1871	Silver-lead, gold, copper (zinc)
56.	Battle Mt., Nevada	1871	Copper, silver, gold
57.	Tybo, Nevada	1874	Silver-lead (zinc)
58.	Union, Nevada	1872	Gold, silver, lead
59.	Echo, Nevada	1871	Silver, gold
60.	Oro Blanco, Arizona	1873	Gold
61.	Pima, Arizona	1876	Silver-lead, copper, (zinc)
62.	Leadville, Colorado	1875	Silver-lead (zinc)
63.	Globe, Arizona	1876	Silver
64.	Frisco, Utah	1876	Silver, copper, lead, (zinc)
65.	Homestake, South Dakota	1877	Gold
66.	Tombstone, Arizona	1879	Silver-lead (zinc)
67.	Morenci, Arizona	1879	Copper
68.	Rico, Colorado	1879	Silver-lead (zinc)
69.	Bodie, California	1879	Silver, gold
70.	Tintic, Utah	1879	Silver-lead (zinc)
71.	Gibbonsville, Idaho	1880	Gold
72.	Marysville, Montana	1880	Gold
73.	Elkhorn, Montana	1876	Gold
74.	Eldorado, Nevada	1877	Gold
75.	Paradise Valley, Nevada	1879	Silver, gold
76.	Lewis, Nevada	1878	Silver, gold
77.	Bristol, Nevada	1878	Silver, copper, lead, gold
78.	Rochester, Nevada	1876	Silver, gold
79.	Hillsboro, New Mexico	1878	Gold
80.	Lake Valley, New Mexico	1878	Silver-lead
81	Southwest Oregon	1880	Gold
82.	Bonanza, Colorado	1880	Silver
83.	Old Dominion, Arizona	1881	Copper
84.	Wood River, Idaho	1881	Silver, gold, lead
85.	Red Cliff, Colorado (Gilman)	1882	Gold (zinc)

Table B-6 (continued)

	District	Date Production Started	Principal Metals Recovered
86.	Bayard, New Mexico	1882	Silver, copper, lead (zinc)
87.	Johnson Camp, Arizona	1882	Copper, silver (zinc)
88.	Butte, Montana	1882	Copper
89.	Colville, Washington	1883	Lead
90.	Shafter, Texas	1883	Silver
91.	Neihart, Montana	1881	Silver-lead
92.	Mogollon, New Mexico	1885	Silver, gold
93.	Bisbee, Arizona	1885	Copper
94.	Calico, California	1883	Silver
95.	Aspen, Colorado	1884	Silver-lead
96.	Garfield, Nevada	1885	Silver, gold
97.	Taylor, Nevada	1883	Silver, gold
98.	Courtland-Gleeson, Arizona	1883	Copper, lead, silver, gold
99.	Boulder Creek, Montana	1885	Gold
100.	Coeur d'Alene, Idaho	1886	Silver-lead (zinc)
101.	Mammoth, Arizona	1886	Gold (molybdenum)
102.	Jerome, Arizona	1888	Copper
103.	Castle Mt., Montana	1888	Silver-lead, copper, (zinc)
104.	Pend Oreille, Idaho	1889	Gold
105.	Hawthorne, Nevada	1888	Lead-silver, copper
106.	Crown King, Arizona	1890	Gold, silver
107.	Mercury, Utah	1890	Gold
108.	Creede, Colorado	1891	Silver
109.	Cook's Peak, New Mexico	1892	Silver-lead
110.	Goodsprings, Nevada	1894	Silver-lead (zinc)
111.	Cochiti, New Mexico	1894	Gold, silver
112.	Mohave, California	1895	Gold, silver
113.	Delamar, Nevada	1895	Gold
114.	Congress, Arizona	1894	Gold
115.	Harquahala, Arizona	1891	Gold
116.	California dredges	1896	Gold
117.	Bingham, Utah	1897	Copper
118.	Cripple Creek, Colorado	1898	Gold
119.	Lordsburg, New Mexico	1899	Copper
120.	York, Montana	1895	Gold
121.	Randsburg, California	1896	Gold, silver
122.	Shasta, California	1896	Copper
123.	Bigbug, Arizona	1898	Gold, silver
124.	Kofa, Arizona	1897	Gold
125.	Fortuna, Arizona	1897	Gold
126.	Georgetown, Montana	1900	Gold
127.	Garnet, Montana	1896	Gold
128.	Renova, Montana	1896	Gold
129.	Octave, Arizona	1900	Gold
130.	Hanover, New Mexico	1902	Zinc

Table B-6 (continued)

	District	Date Production Started	Principal Metals Recovered
131.	Tonopah, Arizona	1903	Silver
132.	Republic, Washington	1903	Gold
133.	Magdalena, New Mexico	1903	Zinc
134.	Manhattan, Nevada	1905	Gold
135.	Allegahany, California	1902	Gold
136.	Searchlight, Nevada	1902	Gold
137.	Weepah, Nevada	1904	Gold, silver
138.	Safford, Nevada	1903	Silver, gold, lead, copper
139.	Katherine, Arizona	1903	Gold
140.	Warm Springs, Montana	1901	Gold
141.	Landusky, Montana	1903	Gold
142.	Goldfield, Nevada	1906	Gold
143.	Iron King, Arizona	1906	Gold, silver, lead, zinc, copper
144.	Silver Peak, Nevada	1908	Gold, silver
145.	Ely, Nevada	1908	Copper
146.	Oatman, Arizona	1910	Gold
147.	Wallapai, Arizona	1906-12	Gold
148.	National, Nevada	1908	Gold, silver
149.	Fairview, Nevada	1907	Silver, gold
150.	Bullfrog, Nevada	1907	Gold, silver
151.	Round Mt., Nevada	1907	Gold, silver, lead
152.	Winston, Montana	1908	Gold
153.	Kendall, Montana	1910	Gold
154.	Ray, Arizona	1911	Copper
155.	Miami, Arizona	1911	Copper
156.	Chino, New Mexico	1911	Copper
157.	Yerington, Nevada	1912	Copper
158.	Magma, Arizona	1913	Copper
159.	Inspiration, Arizona	1915	Copper
160.	Engels, California	1914	Copper
161.	Clark Fork, Idaho	1913	Silver-lead
162.	Wonder, Nevada	1911	Silver, gold, copper, zinc
163.	Midas, Nevada	1911	Gold, silver
164.	Buckhorn, Nevada	1914	Gold, silver, lead
165.	Jarbidge, Nevada	1916	Gold
166.	Ruby, Arizona	1916	Lead-zinc, silver
167.	Ajo, Arizona	1917	Copper
168.	Walker, California	1916	Copper
169.	Bell, Arizona	1917	Silver-lead, zinc
170.	Santa Fe, Nevada	1916	Copper, silver, gold, lead
171.	Pilot Mts., Nevada	1916	Mercury, silver, gold, lead

Table B-6 (continued)

	District	Date Production Started	Principal Metals Recovered
172.	Questa, New Mexico	1923	Molybdenum
173.	Climax, Colorado	1924	Molybdenum
174.	Stemple, Montana	1922	Gold
175.	Metaline, Washington	1930	Zinc-lead
176.	Aravaipa, Arizona	1927	Zinc-lead
177.	Bruner, Nevada	1926	Gold, silver
178.	Pecos, New Mexico	1926	Zinc, lead, copper
179.	Argenta, Montana	1926	Gold
180.	Yellow Pine, Idaho	1932	Gold, antimony, mercury
181.	Humbug, Arizona	1932	Gold
182.	Silver Star, Montana	1935	Gold
183.	Getchell, Nevada	1938	Gold
184.	Bagdad, Arizona	1937	Copper
185.	Crodero, Nevada	1940	Mercury
186.	Castle Dome, Arizona	1943	Copper
187.	Pima, Arizona	1953	Copper
188.	Riddle, Oregon	1954	Nickel
189.	Copper Cities, Arizona	1954	Copper
190.	San Manuel, Arizona	1956	Copper, molybdenum
191.	Esperanza, Arizona	1959	Copper, molybdenum
192.	Mission, Arizona	1961	Copper, molybdenum
193.	Mineral Park, Arizona	1964	Copper, molybdenum
194.	Carlin. Nevada	1965	Gold
195.	Uravan Mineral Belt, Colorado	1898	uranium
196.	Big Indian Wash, Utah	1952	uranium
197.	Grants, New Mexico	1952	uranium
198.	Gas Hills, Wyoming	1954	uranium

APPENDIX C

THE GEOGRAPHIC DISTRIBUTION OF SELECTED NONFUEL MINERAL OUTPUT IN THE UNITED STATES

(Data relevant to Chapter 4)

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Table C-1

GEOGRAPHIC DISTRIBUTION OF GOLD PRODUCTION IN THE UNITED STATES

Year	Percent of Total United States Production				
	South Dakota	Nevada	Utah	Washington + Arizona	Others
1947	19.3	4.2	20.0	6.3	29.9
1948	18.7	5.6	18.3	8.9	27.7
1949	23.3	6.5	15.8	9.1	24.5
1950	27.7	7.5	19.1	8.8	23.8
1951	23.1	6.1	21.8	9.2	22.8
1952	25.5	6.2	23.0	8.8	22.9
1953	27.3	5.2	24.7	9.0	21.9
1954	29.5	4.3	21.9	9.9	21.4
1955	28.2	3.9	23.5	10.7	20.4
1956	31.1	3.7	22.8	11.9	19.9
1957	31.6	4.3	21.1	12.9	20.5
1958	32.8	6.0	17.7	14.0	18.8
1959	36.1	7.0	15.0	14.8	18.1
1960	33.3	3.5	22.1	16.0	17.7
1961	36.1	3.5	22.2	17.0	14.4
1962	37.4	4.1	20.2	15.4	16.0
1963	39.7	6.8	14.7	16.3	11.5
1964	42.8	1.2	19.8	17.2	9.5
1965	36.8	13.4	25.0	16.0	7.1
1966	33.6	20.4	24.3	12.5	5.6
1967	38.0	27.5	18.2	7.7	6.0
1970	43.71P	3.05 - 48.63P	21.76P	16.12P	4.21P
1975	48.58P	2.38 - 83.88P	22.14P	17.57P	--P
1980	53.45P	1.71 - 100.00P	22.52P	19.02P	--P
1985	58.32P	1.03 - 100.00P	22.91P	20.48P	--P
	$\bar{\bar{y}}_{sd} = .974x + 20.333$	$\bar{\bar{y}}_{n1} = -.134x + 6.277$ $\bar{\bar{y}}_{n2} = 7.05x + 6.333$	$\bar{\bar{y}}_{u} = .077x + 19.919$	$\bar{\bar{y}}_{w+a} = .291x + 9.133$	$\bar{\bar{y}}_{o} = -1.071x + 29.929$
	$\sigma = 2.56$	$\sigma = 1.53$ $\sigma = .0292$	$\sigma = 2.77$	$\sigma = 2.58$	$\sigma = 1.78$

p = projection of existing trend

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, The University of Arizona.

Table C-2

GEOGRAPHIC DISTRIBUTION OF SILVER PRODUCTION IN THE UNITED STATES

Percent of Total United States Production

Year	Idaho	Utah	Arizona	Montana	Colorado	Nevada	Others
1947	28.9	21.7	12.8	17.7	7.1	3.8	8.0
1948	30.1	21.1	12.7	18.2	7.9	4.7	5.3
1949	29.0	19.4	14.3	18.3	8.3	5.2	5.5
1950	37.9	16.7	12.6	15.5	8.2	3.6	5.5
1951	37.1	18.4	12.9	16.1	7.0	2.4	6.1
1952	37.8	18.2	11.9	15.6	7.1	2.4	7.0
1953	39.0	17.9	11.6	17.8	5.8	1.9	6.0
1954	43.0	16.7	11.6	14.0	9.3	1.5	3.9
1955	37.2	16.8	12.4	16.3	7.5	2.3	7.5
1956	34.8	17.0	13.4	19.1	5.9	2.5	7.3
1957	39.5	16.2	13.8	14.6	7.3	2.5	6.1
1958	46.8	15.5	13.7	10.7	6.0	2.7	4.6
1959	53.3	12.0	12.5	11.0	4.3	1.9	5.0
1960	44.4	15.5	15.5	11.7	5.4	2.3	5.2
1961	50.5	14.7	14.7	10.0	5.7	1.1	4.2
1962	48.3	14.8	14.8	12.4	5.7	.6	5.6
1963	47.4	15.2	15.2	12.0	6.6	.6	4.6
1964	45.4	16.0	16.0	14.5	7.2	.5	3.9
1965	46.4	15.3	15.3	13.1	5.2	1.3	4.5
1966	45.3	14.5	14.5	12.2	4.8	2.0	3.5
1967	53.0	14.3	14.3	6.4	5.7	1.8	3.6
1970	54.82P	11.94P	15.52P	8.89P	4.87P	.21P	3.57P
1975	59.88P	10.26P	16.24P	6.87P	4.21P	-.59P	2.88P
1980	64.94P	8.57P	16.95P	4.85P	3.55P	-1.39P	2.18P
1985	69.99P	6.88P	17.57P	2.83P	3.90P	-2.19P	1.49P
	$\bar{\bar{y}} = 1.012x + 30.538$	$\bar{\bar{y}} = -.338x + 20.048$	$\bar{\bar{y}} = .143x + 12.095$	$\bar{\bar{y}} = -.404x + 18.586$	$\bar{\bar{y}} = -.131x + 18.014$	$\bar{\bar{y}} = -.160x + 4.043$	$y = -.139x + 6.910$
	$\sigma = 3.94$	$\sigma = 1.71$	$\sigma = .95$	$\sigma = 2.09$	$\sigma = .98$	$\sigma = .80$	$\sigma = .98$

p = Projection of existing trend.

Source of Data: U.S. Bureau of Mines 1947-1967. Projections by Division of Business and Economic Research, the University of Arizona.

Table C-3

GEOGRAPHIC DISTRIBUTION OF LEAD PRODUCTION IN THE UNITED STATES

Year	Percent of United States Production Missouri	Utah	Idaho	Composite Western States (Mont., Ariz., Col., & Wash.)
1947	34.4	12.9	20.6	17.7
1948	26.2	14.3	22.7	20.9
1949	31.1	12.9	19.3	20.4
1950	31.2	10.4	23.2	19.8
1951	31.9	13.0	19.8	19.3
1952	33.1	12.9	18.9	19.9
1953	36.7	12.1	21.8	18.4
1954	38.5	13.8	21.3	16.1
1955	37.1	14.9	19.0	15.7
1956	35.1	14.1	18.2	17.3
1957	37.3	13.1	21.2	17.7
1958	42.3	15.1	20.0	16.1
1959	41.2	14.3	24.4	16.0
1960	45.4	16.0	17.4	15.8
1961	37.7	15.6	27.3	13.2
1962	25.7	16.1	35.5	15.9
1963	31.5	17.8	29.9	14.3
1964	42.0	14.1	24.9	13.4
1965	44.3	12.5	22.1	13.6
1966	40.4	19.6	22.1	11.4
1967	48.1	17.0	19.4	9.6
1970	44.31P	17.32P	25.42P	10.54P
1975	47.23P	18.43P	26.61P	8.32P
1980	50.16P	19.54P	27.80P	6.01P
1985	53.08P	30.65P	28.99P	3.86P
	$\bar{\bar{Y}}_M = .584x + 30.286$	$\bar{\bar{Y}}_U = .22x + 11.986$	$\bar{\bar{Y}}_I = .238x + 19.719$	$\bar{\bar{Y}}_{WC} = -.445x + 21.233$
	$= 4.82$	$= 1.56$	$= 4.02$	$= 1.27$

p = Projection of existing trend.

Source of Data: U.S. Bureau of Mines 1947-1967. Projections by Division of Economic and Business Research, The University of Arizona.

Table C-4

GEOGRAPHIC DISTRIBUTION OF ZINC PRODUCTION IN THE UNITED STATES

	Percent Of Total United States Production		
Year	**Tennessee**	**New York**	**Composite Western States**
1947	4.9	5.4	32.8
1948	4.7	5.5	34.0
1949	5.0	6.4	32.8
1950	5.7	6.1	31.2
1951	5.7	5.9	31.4
1952	5.7	4.9	31.8
1953	7.0	9.4	27.4
1954	6.4	11.2	27.6
1955	7.8	10.3	28.7
1956	8.5	10.9	30.8
1957	10.9	12.2	33.5
1958	14.3	12.9	34.2
1959	21.1	10.2	30.8
1960	21.0	15.2	27.0
1961	17.6	11.8	34.7
1962	14.2	10.6	32.2
1963	18.1	10.1	30.3
1964	20.2	10.6	30.3
1965	20.0	11.4	28.9
1966	18.0	12.8	31.9
1967	20.6	12.8	30.0
1970	24.70^{p}	14.65^{p}	30.12^{p}
1975	29.49^{p}	16.50^{p}	29.74^{p}
1980	34.28^{p}	18.34^{p}	29.36^{p}
1985	39.07^{p}	20.18^{p}	28.99^{p}

$\bar{\bar{y}}_t = .958x + 1.695$ $\qquad$ $\bar{\bar{y}}_{ny} = .369x + 5.800$ $\qquad$ $\bar{\bar{y}}_{cw} = -.075x + 31.924$

$\sigma = 2.67$ $\qquad$ $\sigma = 1.85$ $\qquad$ $\sigma = 2.13$

p = Projection of existing trend

Source of Data: U.S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, The University of Arizona.

Table C-5

GEOGRAPHIC DISTRIBUTION OF IRON ORE PRODUCTION IN THE UNITED STATES

Year	California	Wyoming	Utah	Michigan & Minnesota	Others
	Percent of Total United States Production				
1947	1	1	3	81	14
1948	.5	1	3	80	15.5
1949	1	1	3	79	15
1950	1	1	3	79	15
1951	1	1	4	78	16
1952	2	1	4	78	15
1953	2	1	4	79	14
1954	1	1	4	77	17
1955	1	1	4	79	15
1956	1	1	4	77	17
1957	2	1	4	77	16
1958	3	1	6	74	16
1959	3	2	5	72	18
1960	2	2	3	79	14
1961	4	1	6	73	16
1962	4	1	4	75	15
1963	5	3	3	75	14
1964	6	2	2	75	15
1965	6	2	2	76	14
1966	7	2	2	76	13
1967	7	2	2	77	12
1970	6.94^{P}	2.24^{P}	3.05^{P}	73.64^{P}	14.01^{P}
1975	8.49^{P}	2.57^{P}	2.85^{P}	72.37^{P}	13.60^{P}
1980	10.04^{P}	2.90^{P}	2.65^{P}	71.10^{P}	13.18^{P}
1985	11.60^{P}	3.24^{P}	2.44^{P}	69.83^{P}	12.77^{P}
	$\bar{\bar{y}}_c = .310x + -.510$	$\bar{\bar{y}}_w = .066x + .652$	$\bar{\bar{y}}_u = -.040x + 4.014$	$\bar{\bar{y}}_{m\&m} = .225x + 79.752$	$\bar{\bar{y}}_o = -.083x + 16.010$
	$\sigma = .96$	$\sigma = .42$	$\sigma = 1.14$	$\sigma = 3.49$	$\sigma = 2.63$

p = Projection of existing trend

Source of Data: U.S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, The University of Arizona.

Table C-6

GEOGRAPHIC DISTRIBUTION OF COPPER PRODUCTION IN THE UNITED STATES

Year	Arizona	Montana	Utah	Nevada	New Mexico	Michigan	Others
			Percent of Total United States Production				
1947	43.2	6.8	31.4	5.9	7.1	2.7	2.7
1949	44.9	7.0	27.2	5.4	9.0	3.3	3.2
1949	47.7	7.5	26.2	5.1	7.3	3.6	3.6
1950	44.4	6.0	30.6	5.8	7.3	2.8	3.1
1951	44.8	6.2	29.2	6.1	7.9	2.7	3.1
1952	42.8	6.7	30.6	6.2	8.2	2.3	3.2
1953	42.5	8.4	29.1	6.7	7.8	2.6	2.9
1954	45.2	7.1	25.4	8.4	7.3	2.8	3.8
1955	45.5	8.2	23.3	7.9	6.6	5.0	3.5
1956	45.8	8.8	22.7	7.3	6.7	5.6	3.1
1957	47.5	8.4	21.9	7.1	6.2	5.4	3.5
1958	49.6	9.3	19.3	6.7	5.7	5.9	3.5
1959	52.2	8.0	17.5	7.0	4.8	6.7	3.8
1960	49.9	8.5	20.2	7.2	6.2	5.2	1.8
1961	50.4	8.9	18.3	6.7	6.9	6.0	2.8
1962	52.5	7.7	17.7	6.7	6.7	6.0	2.7
1963	54.5	6.6	16.8	6.7	6.8	6.2	2.4
1964	55.4	8.3	16.0	5.4	6.9	5.6	2.4
1965	52.0	8.5	19.2	5.3	7.3	5.3	2.4
1966	51.7	9.0	18.6	5.5	7.6	5.1	2.5
1967	52.6	6.9	17.7	5.3	7.9	6.1	3.5
1970	55.44^P	8.66^P	12.95^P	6.35^P	6.52^P	7.19^P	2.62^P
1975	58.13^P	9.00^P	9.16^P	6.33^P	6.32^P	8.19^P	2.44^P
1980	60.82^P	9.35^P	5.37^P	6.32^P	6.12^P	9.20^P	2.26^P
1985	63.52^P	9.69^P	1.57^P	6.30^P	5.92^P	10.21^P	2.08^P
	$\bar{\bar{Y}}_A = .539x + 42.500$	$\bar{\bar{Y}}_{Ma} = .069x + 7.005$	$\bar{\bar{Y}}_U = -.758x + 31.152$	$\bar{\bar{Y}}_N = -.0026x + 6.450$	$\bar{\bar{Y}}_{NM} = -.040x + 7.490$	$\bar{\bar{Y}}_{Mn} = .201x + 3.495$	$Y_O = -.036x + 3.495$
	$\sigma = 2.02$	$\sigma = .82$	$\sigma = 2.26$	$\sigma = 1.09$	$\sigma = .87$	$\sigma = .90$	$\sigma = .43$

p = Projection of existing trend.

Source of Data: U.S. Bureau of Mines 1947-1967. Projections from Division of Economic and Business Research, the University of Arizona.

Table C-7

GEOGRAPHIC DISTRIBUTION OF MERCURY PRODUCTION IN THE UNITED STATES

Year	Percent of Total United States Production		
	California	Nevada	Others
1947	73.9	16.7	9.4
1948	77.8	8.4	14.8
1949	45.2	42.0	12.8
1950	84.9	15.0	.1
1951	58.7	19.2	22.1
1952	57.7	28.1	14.2
1953	64.8	22.7	10.5
1954	60.7	26.8	12.5
1955	52.1	30.3	17.6
1956	37.3	24.3	38.4
1957	47.7	18.2	34.1
1958	58.8	19.3	21.9
1959	54.7	22.9	22.4
1960	56.5	23.6	19.9
1961	59.0	23.7	17.3
1962	60.7	25.0	14.3
1963	71.0	25.9	3.1
1964	72.8	23.1	4.1
1965	68.5	17.0	14.5
1966	73.0	15.2	11.8
1967	68.9	19.8	11.3
1970	63.58^{p}	24.35^{p}	14.96^{p}
1975	64.13^{p}	25.16^{p}	14.73^{p}
1980	64.68^{p}	25.97^{p}	14.50^{p}
1985	65.23^{p}	26.78^{p}	14.26^{p}
	$\bar{\bar{y}}_c = .110x + 60.929$	$\bar{\bar{y}}_n = .162x + 20.452$	$\bar{\bar{y}}_o = .047x + 16.086$
	$\sigma = 11.51$	$\sigma = 6.96$	$\sigma = 8.77$

p = Projection of existing trend

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, The University of Arizona.

Table C-8

GEOGRAPHIC DISTRIBUTION OF MOLYBDENUM PRODUCTION IN THE UNITED STATES

Year	Percent of Total United States Production		
	Colorado	New Mexico	Others
1947	43	.6	56.4
1948	49	.8	50.2
1949	48	1.0	51
1950	42	.6	57.4
1951	58	.7	41.3
1952	55	.3	44.7
1953	65	.2	34.8
1954	73	.2	26.8
1955	70	.1	29.9
1956	65	.05	34.95
1957	70	0	30
1958	59	0	41
1959	72	0	28
1960	73	0	27
1961	72	0	28
1962	64	0	36
1963	73	0	27
1964	62	0	28
1965	65	0	35
1966	62	9	29
1967	67	11	21
1970	77.30^p	17^p	18.71^p
1975	82.91^p	27^p	12.04^p
1980	88.52^p	37^p	5.37^p
1985	94.13^p	47^p	$-^p$

$\bar{\bar{y}}_c = 1.122x + 50.371$ $\quad$ $\bar{\bar{y}}_{nm_1} = -.039x + .670$ $\quad$ $\bar{\bar{y}}_o = -1.334x + 50.719$

$\sigma = 7.30$ $\quad$ $y_{nm_2} = 2x + 9$ $\quad$ $\sigma = 6.46$

$\sigma = .180$

p = Projection of existing trend

Source of data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, The University of Arizona.

Table C-9

GEOGRAPHIC DISTRIBUTION OF URANIUM ORE PRODUCTION IN THE UNITED STATES

Year	New Mexico	Wyoming	Colorado	Utah	Arizona	Others
1947						
1948	3.3	0	70.0	5.6	21.1	0.0
1949	1.6	0	64.6	15.7	18.0	0.1
1950	0.8	0.1	56.6	22.4	20.0	0.8
1951	2.9	0	50.9	20.4	25.0	1.2
1952	2.7	0.1	52.7	19.3	24.0	1.1
1953	8.9	0.8	38.0	31.1	20.1	1.0
1954	18.4	1.2	28.7	33.9	16.7	1.6
1955	13.9	2.6	23.3	48.0	10.6	1.1
1956	34.4	4.2	17.3	35.4	7.6	2.5
1957	27.0	6.2	19.4	37.0	7.9	3.1
1958	30.1	12.3	19.4	29.0	6.1	3.5
1959	39.8	12.9	15.7	23.6	4.4	3.6
1960	42.5	18.5	14.5	16.7	4.0	3.8
1961	42.0	20.5	14.4	16.4	3.2	3.6
1962	46.6	18.1	13.8	16.1	2.3	1.1
1963	34.9	23.7	14.1	18.7	3.6	4.8
1964	39.2	21.8	12.9	21.7	2.7	6.6
1965	44.8	21.7	13.4	10.8	4.3	5.1
1966	48.3	23.8	14.5	6.8	2.3	4.2
1967	51.7	22.7	12.5	6.6	0.4	4.6
1970	63.00P	30.37P	-P	9.09P	-P	6.16P
1975	77.52P	38.30P	-P	4.03P	-P	7.56P
1980	92.00P	46.23P	-P	-P	-P	8.96P
1985	100.00P	54.16P	-P	-P	-P	10.36P
	$\bar{\bar{y}}_{nm} = 2.904x + (-.3.789)$	$\bar{\bar{y}}_w = 1.586x + (-6.100)$	$\bar{\bar{y}}_c = 2.919x + 59.005$	$\bar{\bar{y}}_u = -1.012x + 32.384$	$\bar{\bar{y}}_a = -1.280x + 23.637$	$\bar{\bar{y}}_o = .280x + (-.295)$
	$\sigma = 5.85$	$\sigma = 2.88$	$\sigma = 8.84$	$\sigma = 10.71$	$\sigma = 3.78$	$\sigma = .91$

p = Projection of existing trend

Source of Data: U.S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, the University of Arizona.

Table C-10

GEOGRAPHIC DISTRIBUTION OF PHOSPHATE ROCK PRODUCTION IN THE UNITED STATES

Year	Percent of Total United States Production Western Field	Florida	Tennessee
1947	4	72	14
1948	7	79	14
1949	9	78	13
1950	8	80	12
1951	10	79	11
1952	10	80	10
1953	11	79	10
1954	11	79	10
1955	14	76	10
1956	12	79	9
1957	12	77	11
1958	13	77	10
1959	14	77	9
1960	17	74	9
1961	12	78	10
1962	14	76	10
1963	13	77	10
1964	13	78	9
1965	15	77	8
1966	15	78	7
1967	14	80	6
1970	17.14^{p}	79.07^{p}	6.48^{p}
1975	19.20^{p}	79.81^{p}	5.09^{p}
1980	21.25^{p}	80.55^{p}	3.70^{p}
1985	23.30^{p}	81.29^{p}	2.31^{p}
	$\bar{\bar{y}}_w = .410x + 7.295$	$\bar{\bar{y}}_f = .148x + 75.514$	$\bar{\bar{y}}_t = -.278x + 13.152$
	$\sigma = 1.67$	$\sigma = 2.25$	$\sigma = 1.01$

p = Projection of existing trend

Source of Data: U.S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, The University of Arizona.

APPENDIX D

THE AVERAGE GRADE OF NONFUEL MINERALS MINED IN THE UNITED STATES

(Data relevant to Chapter 4)

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Table D-1

AVERAGE RECOVERABLE CONTENT OF MINERAL COMMODITIES FROM ORE MINED IN THE UNITED STATES, PRECIOUS METALS

Year	Gold From Gold Ore (oz./ton)	Placer Gold (oz./yd.^{3})	Silver From Silver Ore (oz./ton)
1947	.220	.0048	19.546
1948	.229	.0044	20.109
1949	.254	.0043	12.599
1950	.277	.0049	17.956
1951	.286	.0046	22.522
1952	.311	.0054	22.369
1953	.354	.0056	18.557
1954	.340	.0062	20.355
1955	.344	.0071	18.381
1956	.339	.0067	14.839
1957	.325	.0070	16.001
1958	.331	.0078	20.208
1959	.346	.0088	21.765
1960	.345	.0074	16.100
1961	.355	.0056	22.468
1962	.333	.0095	20.423
1963	.300	.0093	18.830
1964	.298	.0080	17.009
1965	.296	.0065	14.902
1966	.299	.0063	13.468
1967	.352	.0084	13.608
1970	.352	.0090	16.354
1975	.370	.0099	15.448
1980	.387	.0109	14.641
1985	.404	.0110	13.835
	$\bar{\bar{Y}}au=.0034x + .273$ $\sigma=.0343$	$\bar{\bar{Y}}au(p)=.000196x + .00445$ $\sigma=.00112$	$\bar{\bar{Y}}ag=-.1613x + 19.966$ $\sigma=2.957$

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by the Division of Economic and Business Research, the University of Arizona.

Table D-2

AVERAGE RECOVERABLE CONTENT OF MINERAL COMMODITIES FROM ORE MINED IN THE UNITED STATES, BASE METALS

Year	Copper (%)	Zinc (%)	Lead (%)	Iron (%)
1947	.90	5.3	2.7	41
1948	.92	5.6	2.7	40
1949	.91	5.5	2.5	40
1950	.89	5.5	2.6	39
1951	.90	5.3	2.4	39
1952	.85	10.4	2.5	38
1953	.85	9.2	2.3	38
1954	.83	13.7	2.4	36
1955	.83	11.5	2.3	34
1956	.78	5.3	2.3	34
1957	.77	4.1	1.6	34
1958	.79	4.0	2.0	33
1959	.74	3.7	2.1	31
1960	.73	3.5	2.1	31
1961	.75	3.9	2.2	28
1962	.75	3.9	2.6	28
1963	.74	3.7	2.9	27
1964	.73	3.9	2.8	28
1965	.70	3.9	2.8	28
1966	.67	3.7	2.9	28
1967	.63	3.8	3.0	27
1970	$.623^p$	3.07^p	2.64^p	24.05^p
1975	$.558^p$	2.00^p	2.71^p	20.02^p
1980	$.492^p$	$.917^p$	2.78^p	16.11^p
1985	$.427^p$	–	2.85^p	12.15^p
	$\bar{\bar{Y}}cu=.003x + .937$	$\bar{\bar{Y}}zn=-.217x + 8.070$	$\bar{\bar{Y}}pb=.014x + 2.311$	$\bar{\bar{Y}}fe=-.794x + 42.300$
	$\sigma = .0195$	$\sigma = 2.610$	$\sigma = .1273$	$\sigma = 1.406$

p = projection of existing trend

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, The University of Arizona.

Table D-3

AVERAGE RECOVERABLE CONTENT OF MINERAL COMMODITIES FROM ORE MINED IN THE UNITED STATES, OTHER METALS

Year	Uranium ($\%U_3O_8$)	Molybdenum (%)	Mercury (lb/ton)	Nickel (%)
1947			12.5	
1948	.218		10.2	
1949	.289		10.3	
1950	.315		9.3	
1951	.306	.27	6.5	
1952	.332	.30	7.0	
1953	.313	.32	7.8	
1954	.320	.27	8.1	1.50
1955	.291	.26	6.4	1.47
1956	.280	.22	7.5	1.47
1957	.265	.20	8.4	1.50
1958	.260	.20	8.6	1.50
1959	.250	.20	8.6	1.50
1960	.237	.21	9.7	1.51
1961	.234	.19	9.2	1.46
1962	.241	.20	13.6	1.50
1963	.253	.19	12.8	1.50
1964	.258	.17	7.2	1.44
1965	.239	.18	4.3	1.41
1966	.230	.19	5.2	1.44
1967	.202	.20	4.1	1.41
1970	.218	.148	6.81	1.41
1975	.198	.111	6.12	1.39
1980	.177	.086	5.44	1.36
1985	.156	.052	5.75	1.33
	$\bar{\bar{Y}}u=-.0052x + .311$	$\bar{\bar{Y}}mo=-.0074x + .288$	$\bar{\bar{Y}}hg=-.136x + 9.943$	$\bar{\bar{Y}}ni=-.0055x + 1.514$
	$\sigma = .0282$	$\sigma = .0254$	$\sigma = 2.421$	$\sigma = .026$

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, the University of Arizona.

Table D-4

AVERAGE RECOVERABLE CONTENT OF MINERAL COMMODITIES FROM ORE MINED IN THE UNITED STATES, INDUSTRIAL MINERALS

Year	Phosphate (%P_20_5)
1947	12
1948	12
1949	12
1950	12
1951	12
1952	12
1953	13
1954	13
1955	12
1956	12
1957	12
1958	12
1959	12
1960	15
1961	15
1962	16
1963	16
1964	17
1965	17
1966	16
1967	15
1970	16.67
1975	17.96
1980	19.25
1985	20.54

$$\bar{\bar{Y}}_{P_20_5} = .258x + 10.729$$

$$\sigma = 1.12$$

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, the University of Arizona.

APPENDIX E

BY–PRODUCT MINERAL PRODUCTION IN THE UNITED STATES

(Data relevant to Chapter 4)

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Table E-1

PROPORTION OF GOLD PRODUCED IN THE UNITED STATES AS A BY-PRODUCT FROM ORES OF OTHER METALS
1947 - 1967

Year	Total Domestic Output (troy ounces)	Proportion Produced as a By-product (percent)
1947	2,109,000	69
1948	2,014,000	73
1949	1,992,000	66
1950	2,394,000	66
1951	1,981,000	69
1952	1,893,000	67
1953	1,958,000	66
1954	1,837,000	63
1955	1,880,000	63
1956	1,827,000	62
1957	1,794,000	61
1958	1,739,000	60
1959	1,603,000	54
1960	1,667,000	56
1961	1,548,000	54
1962	1,543,000	55
1963	1,454,000	50
1964	1,456,000	51
1965	1,705,000	47
1966	1,803,000	43
1967	1,584,000	32

Source of Data: U.S. Bureau of Mines.

Table E-2

SILVER PRODUCED IN THE UNITED STATES AS A BY-PRODUCT OR CO-PRODUCT FROM ORES OF OTHER METALS
1947 - 1967

Year	Total Domestic Production (troy ounces)	Proportion Produced as a By-or Co-product (percent)
1947	35,824,000	86
1948	38,096,000	86
1949	34,675,000	89
1950	42,459,000	80
1951	39,767,000	81
1952	39,452,000	77
1953	37,571,000	82
1954	36,941,000	71
1955	37,198,000	82
1956	38,721,000	75
1957	38,165,000	71
1958	34,111,000	65
1959	31,194,000	60
1960	30,766,000	69
1961	34,794,000	65
1962	36,798,000	71
1963	35,243,000	71
1964	36,334,000	73
1965	39,806,000	70
1966	43,669,000	70
1967	32,119,000	64

Source of Data: U. S. Bureau of Mines.

Table E-3

PROPORTION OF SELECTED FERRO-ALLOY METALS PRODUCED IN THE UNITED STATES AS BY-PRODUCTS FROM ORES OF OTHER METALS

Year	Proportion of By-product Molybdenum Output (percent of domestic production)	Proportion of By-product Tungsten Output (percent of domestic production)
1947	57	0
1948	42	4
1949	51	8
1950	58	4
1951	46	5
1952	45	7
1953	35	5
1954	27	5
1955	30	5
1956	35	4
1957	30	1
1958	39	33
1959	28	25
1960	27	10
1961	28	19
1962	36	13
1963	27	13
1964	28	15
1965	35	16
1966	29	17
1967	23	14

Source of Data: U. S. Bureau of Mines.

Table E-4

PROPORTION OF LEAD PRODUCED IN THE UNITED STATES AS A BY-PRODUCT OR CO-PRODUCT FROM ORES OF OTHER METALS

1947 - 1967

Year	Total Domestic Production (tons)	Proportion Produced as a By- or Co-product (percent)
1947	384,000	58
1948	390,000	65
1949	410,000	61
1950	431,000	61
1951	388,000	62
1952	390,000	57
1953	343,000	56
1954	325,000	52
1955	338,000	54
1956	353,000	56
1957	338,000	54
1958	267,000	53
1959	256,000	56
1960	247,000	47
1961	262,000	55
1962	237,000	64
1963	253,000	60
1964	286,000	49
1965	301,000	47
1966	327,000	50
1967	317,000	45

Source of Data: U. S. Bureau of Mines.

Table E-5

PROPORTION OF ZINC PRODUCED IN THE UNITED STATES AS A BY-PRODUCT OR CO-PRODUCT FROM ORES OF OTHER METALS
1947 - 1967

Year	Total Domestic Production (tons)	Proportion Produced as a By- or Co-product (percent)
1947	638,000	64
1948	630,000	62
1949	593,000	69
1950	623,000	69
1951	681,000	66
1952	666,000	54
1953	547,000	62
1954	473,000	54
1955	515,000	65
1956	542,000	70
1957	532,000	62
1958	412,000	68
1959	425,000	64
1960	435,000	62
1961	464,000	62
1962	506,000	59
1963	529,000	56
1964	575,000	48
1965	611,000	47
1966	573,000	48
1967	549,000	46

Source of Data: U. S. Bureau of Mines.

APPENDIX F

MINERAL PRODUCTION FROM THE PUBLIC LANDS

(Data relevant to Chapter 6)

Table F-1

MINERAL PRODUCTION FROM THE PUBLIC LANDS

VALUE OF MINERAL OUTPUT

Year	Phosphates	Potassium Minerals
1920-1944	$2,802,505	$117,586,343
1945	664,538	26,038,303
1946	752,448	26,611,215
1947	891,885	34,238,211
1948	1,738,826	35,594,012
1949	1,765,336	32,982,086
1950	541,917	40,100,638
1951	922,353	41,190,025
1952	1,962,591	53,088,540
1953	1,951,377	52,163,101
1954	1,852,563	58,098,292
1955	2,606,357	58,584,558
1956	2,104,905	59,764,782
1957	3,696,756	55,882,090
1958	3,421,959	69,393,210
1959	3,832,752	78,986,868
1960	3,975,851	72,919,663
1961	3,567,603	88,173,204
1962	3,508,805	90,433,941
1963	3,929,944	94,863,262
1964	5,063,016	108,572,448
1965	10,105,829	107,963,038
1966	8,641,786	94,445,022
1967	7,628,457	69,230,669

Source: U.S. Department of the Interior, 1967, *Mineral Production, Royalty Income and Related Statistics.*

Table F-1 (Continued)

Year	Silica, Silica Sands	Sodium Minerals
1920-1944	$ 19,015	$23,051,954
1945	26,936	5,012,361
1946	26,855	6,788,943
1947	23,356	11,190,411
1948	18,383	12,417,820
1949	17,558	10,973,834
1950	37,153	15,286,064
1951	37,282	14,128,783
1952	36,676	15,198,286
1953	35,088	16,521,526
1954	39,027	19,322,122
1955	36,030	22,568,319
1956	28,455	23,238,686
1957	33,655	22,724,102
1958	23,465	25,245,099
1959	337,048	25,305,013
1960	12,807	26,447,649
1961	37,235	24,001,429
1962	34,731	25,102,949
1963	27,994	35,773,875
1964	991,235	34,027,848
1965	1,457,697	34,618,060
1966	2,190,846	36,134,057
1967	2,158,177	39,462,514

Source: U.S. Department of the Interior, 1967, *Mineral Production, Royalty Income and Related Statistics.*

APPENDIX G

MINERAL PATENTS IN SELECTED STATES

(Data Relevant to Chapter 5)

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Table G-1

MINERAL PATENTS IN SELECTED STATES

Fiscal Years	Mineral Entries Approved Arizona		Mineral Patents Issued Arizona		Mineral Entries Approved Colorado		Mineral Patents Issued Colorado		Mineral Entries Approved Nevada		Mineral Patents Issued Nevada	
	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres	No.	Acres
1947	6	297.74	2	366.19	8	335.42	1	13.26	1	37.46	1	82.64
1948	10	838.23	5	117.51	9	6,563.39	8	2,445.73	3	138.72	2	75.59
1949	11	859.37	15	866.33	23	20,673.42	12	4,307.86	4	350.62	6	2,728.71
1950	14	8,115.23	5	944.46	15	3,667.91	14	13,910.54	1	51.59	6	970.16
1951	12	559.29	2	162.77	20	4,441.46	24	14,149.58	13	1,263.13	5	531.10
1952	5	706.29	8	281.26	10	7,527.01	6	2,472.82	1	20.66	0	.00
1953	24	2,520.36	6	738.48	33	22,095.53	13	4,018.56	3	437.92	4	437.92
1954	4	189.08	13	767.93	32	28,780.82	13	7,742.50	2	422.41	1	20.66
1955	8	355.01	11	1,297.17	3	2,562.67	37	38,264.90	0	.00	0	.00
1956	6	712.50	12	1,581.48	11	7,349.45	11	2,337.63	9	1,068.08	7	646.09
1957												
1958												
1959												
1960	37	5,017.90	15	1.941.13	4	1,605.00	5	2,245.32	2	470.60	2	470.66
1961	51	10,941.00	36	5,390.44	1	477.00	7	5,796.42	10	2,126.00	9	1,726.01
1962	36	6,399.00	26	9,654.43	17	2,149.00	12	434.84	10	2,955.00	10	2,954.72
1963	23	2,214.00	24	1,300.51	10	1,501.00	1	36.03	9	994.00	9	943.67
1964	16	3,759.00	15	1,635.12	4	103.00	4	88.71	1	77.00	2	1,127.65
1965	9	447.00	2	40.00	6	496.00	3	210.00	6	2,137.00	6	2,137.00
1966	17	1,808.00	11	700.94	1	19.00	1	19.00	5	926.00	5	926.00
1967	12	726.00	8	1,396.48	0	.00	0	.00	4	573.00	4	573.00

Source of Data: U. S. Bureau of Land Management.

APPENDIX H

MINERAL PRODUCTION TIME REQUIREMENTS

(Data Relevant to Chapter 9)

APPENDIX H

MINERALS PRODUCTION TIME REQUIREMENTS

Time per Phase of Operation

The time period from the point at which a block of ore has been prepared for mining to the point at which ore from the block is delivered to the concentrator, smelter, or market, as the case may be, varies from a few days to several weeks. Several factors influence production time. In some mining methods (e.g., top slicing, room-and-pillar mining, and open pit mining) ore is removed as soon as it is broken. In other methods (as in shrinkage stoping) some portion of the broken ore must be left in the stope until the stope is mined out.

It is usually desirable from the standpoint of scheduling and sustaining production to have some work done in advance in each of the production stages. If this is not done, then delays in one phase of production may cause delays or stoppages in all subsequent phases of production. On the other hand, advance work represents an expenditure of money on which interest has to be paid until the ore is produced and the expenditure is recovered.

Some minerals such as sulfides will be converted to oxides on exposure to air and water. Some of these oxides are not as readily recovered or upgraded in beneficiation, and resultant process losses are higher. Thus, for some types of ores, it is important that they not be allowed to remain broken and exposed to the air for long periods before beneficiation. Smaller operations will usually have less advance work and fewer scheduling problems, and thus tend to shorten the total production time required. On the other hand, small operations often work fewer shifts per day, and this tends to spread the work out over more days.

Some representative time periods for the various production activities, including delays or waiting periods, in open pit mining are as follows:

Drilling time for average blast	1 to 4 days
Time lapse between drilling and blasting	1 to 4 days
Time to load holes and blast	4 hrs. to 4 days
Mucking time for average blast	2 to 12 days
Time in stockpile before primary crusher	1 hr. to 4 days
Typical total elapsed time from start of production drilling to delivery of all of the ore in a given shot to the concentrator	6 to 24 days

In most underground mining methods, ore that is blast-hole drilled in one or two shifts will be blasted, loaded, and transported out of the mine within the next one or two shifts, so that the total production cycle from the start of blast hole drilling to delivery to the mill is from as little as one day to seldom more than a week. In sublevel caving, shrinkage stoping, and block caving, a number of weeks are usually required either to prepare the stope for mining, to drill and blast, or to draw the ore out of the stope or block. The mass of ore handled as one unit may be the entire mass of ore in the stope or block, and its complete extraction may require from several weeks to several months. These methods require large investments in preliminary work and a larger working capital than most methods.

Leaching and solution methods are relatively slow in their recovery rate and ordinarily require several months to a few years to mine a unit. Furthermore, recovery is usually not higher than 60 to 75 percent.

Time of Production by Commodity

The bulk of *copper* production in the United States comes from sulfide minerals many of which (from the standpoint of recovery in beneficiation) are adversely affected by weathering when exposed to air. Thus, in the mining of copper sulfide ores, a real effort is made to shorten the time the broken ore is exposed to weathering and to deliver it as quickly as practicable to the concentrator. This is often less than one week.

Approximately 16 percent of domestic copper production comes from leaching, mostly of dumps. Dump leaching usually requires several years of alternate wetting and drying to achieve maximum economic recovery, which often is as little as 50 percent of the total copper in the leach material. In the batch leaching processes such as the one being designed at Kennecott Corporation's Ray Mines Division in Arizona, the production cycle will be comparable to that of conventional open pit mill production, a matter of a week or two.

Iron ores are not generally affected by weathering, and the production cycle in iron mining is usually somewhat longer than in copper mining, although the mining methods and operations are similar in most respects. In one iron mine in Michigan, with a production rate of 28,000 tons per day, 50 to 60 blast holes are drilled on 35-foot bench to provide a uniform millfeed for at least a two-week period. Each blast produces about 60,000 tons. Drilling time for 50 holes is approximately 12 shifts, using two drills per shift. Three drill shifts are employed per day so that four days of drilling are required to prepare an area for blasting.

Bedded deposits, which typically include those of *lead, zinc, uranium, phosphate rock, potash, and sodium salts* are mined partly by underground methods, and partly by surface methods. The most common underground method for mining horizontally bedded deposits is open stoping, either with casual pillars or by room-and-pillar. For such minerals the time required from the start of drilling a round to the delivery of that ore to the mill or reduction works is ordinarily from two to three days.

Vein or vein-like deposits that are often steeply dipping include deposits of *gold, silver, tungsten, and mercury.* These deposits are most often mined by supported methods, such as square-set, cut-and-fill, or shrinkage stoping. Except for the ores mined by shrinkage stoping, production time, including the time used to erect supports is from two to five days. In the case of shrinkage stoping, broken ore is drawn from a stope about one-third as fast as it is being produced and much of the broken ore remains in the stope until all of the ore in the stope is blasted down. This may involve months.

Table H-1

AVERAGE LENGTH OF TIME FOR PRODUCTION ACTIVITIES FROM START OF PRODUCTION DRILLING TO DELIVERY OF ORE IN A GIVEN BLAST TO CONCENTRATOR FOR SEVEN OPEN-PIT COPPER MINES IN THE WESTERN UNITED STATES

	Average Time in Days (24 hour periods) Unless Otherwise Noted						
Mine	A	B	C	D	E	F	G
Ore Production	4,500 tpd	15,000 tpd	18,000 tpd	22,500 tpd	30,000 tpd	50,000 tpd	90,000 tpd
Year	1968	15 1968	1968	1968	1968	1959	1964
Drilling time for average blast	1	1	4	1	1 1/2	3	1 1/2
Time delay between end of drilling and blasting	2 1/2	1 1/2	1	1	1	4	1/2
Time to load and blast	4 hrs	4 hrs	1/2	3 hrs	4 hrs	1	1
Time delay between blasting and loading	4 hrs	4 hrs	4 hrs	1	2	4	1
Loading time for average shot	3	9	9	2	2	12	3
Live stockpile capacity at primary crusher	4	1 hrs	1/3	1	12 hrs	10 hrs	4 hrs
Average length of time from start of drilling to delivery to concentrator	11	12-	15	6+	7-	24+	7+

APPENDIX I

MINING COSTS

(Data Relevant to Chapter 9)

Table I-1

DISTRIBUTION OF COSTS

	Pit							
	Berkeley	Tripp	Silver Bell	Copper Cities	Bagdad	Inspiration	Ajo	Weighted average for seven pits
Million tons of solids mined 1/	18.6	14.5	6.1	4.9	8.0	10.1	21.4	2/ 83.6
	Costs in $ per 1,000 tons of solids mined 3/							
Cost allocation:								
Drilling	3.60	16.90	11.90	11.10	29.60	8.40	35.20	18.11
Blasting	14.10	17.30	32.70	11.10	31.20	8.50	30.00	20.87
Shovel loading	24.00	35.50	31.40	51.70	48.10	37.60	28.00	33.13
Haulage	4/ 93.10	5/ 73.70	4/ 112.70	4/ 85.20	4/ 126.80	6/ 132.30	7/ 74.60	93.93
Road and dump maintenance	4.90	9.30	16.30	10.40	23.30	7.00	4.20	8/ 8.65
Supervisory, clerical, and technical personel	11.20	5.00	6.80	3.50	6.00	12.30	26.00	12.78
Other direct expenses	9/ 65.30	15.60	17.20	6.00	10.90	22.90	2.00	23.16
Total Costs, $	216.20	173.30	229.00	179.00	275.90	229.00	200.00	210.63

1/ Includes ore and waste.
2/ Total for seven pits where the ore to waste weight ratio was 1.0 to 1.7.
3/ Includes all labor but not the cost of amortization for development.
4/ All haulage by truck.
5/ Ore hauled 2,000 ft. by truck; waste hauled 3,000 ft. by truck.
6/ Diesel-railroad haulage.
7/ Rail and truck haulage.
8/ Distributed as $5.97 for roads and $2.68 for sumps based on the average of costs experienced at Berkeley, Silver Bell, and Copper Cities. The cost of road maintenance alone was $9.03 at the Yerington open pit.
9/ Includes $40.60 for general expenses.
10/ Equals $568.70 per 1,000 tons of ore produced based on a 1.0 to 1.7 ore to waste weight ratio.

Source: F. D. Cooper and K. L. Wang, *Cost Analysis of the U. S. Copper Industry in 1958*, U. S. Bureau of Mines Open-File Report.

Table I-2

One U.S. establishment comprising an open pit, mill, and smelter had the following expenditures for supplies, parts, and services in 1962.

		$ per 1,000 tons of ore produced and processed	
Materials and supplies	(Steel	$156.00	
	(Explosives	53.80	
	(Timber	23.25	
Subtotal		$213.25	
Processing aids	(Reagents	$360.40	
	(Chemicals and gases	42.53	
	(Other	23.24	
Subtotal		$426.17	
Other supplies	(Office supplies	$ 5.92	
	(Maintenance supplies	185.78	
	(Other	34.08	
Subtotal		$225.78	$ 885.20
Utility Services	(Natural and LP gases	$144.80	
	(Water	8.73	
	(Telephone & telegraph	4.36	
	(Garbage	.14	
Subtotal		$158.03	
Other services	(Freight, common carrier	$336.60	
	(Office, research engineering fees	56.48	
Subtotal		$393.08	$ 551.11
	Grand total		$1,416.51

Source: *1962 Statistical Information for a Western Copper Operation*, U.S. Bureau of Mines files.

Table I-3

AVERAGE COST PER LONG TON OF MINING AND BENEFICIATING IRON ORE IN MINNESOTA

Year	Development	Labor and Supplies	Other[a]	Royalty	Total
1952-56 (average)	$0.625	$0.905	$0.915	$0.433	$2.878
1957	.660	.989	1.145	.474	3.208
1958	.693	.991	1.556	.513	3.753
1959	.757	1.242	1.932	.484	4.415
1960	.755	1.131	1.761	.523	4.170
1961	.787	1.150	2.018	.567	4.522

[a] includes beneficiation.

Source: *Bulletin of the University of Minnesota, Mining Directory Issue.* V. 66, No. 9, May 1, 1963.

Table I-4

COSTS OF BLOCK CAVING DEVELOPMENT AND MINING

Total cost in cents per ton of ore

	In incompetent rock	In competent rock
Zone development	25.0	30.0
Zone mining	18.0	40.0
Ventilation	3.0	3.0
Supervisory, clerical, technical wages	9.0	9.0
Service and miscellaneous expenses	12.0	12.0
Training	11.0	11.0
Level maintenance	5.0	5.0
Equipment maintenance	12.0	14.0
Electric power	5.0	5.0
Repairs to capital equipment	10.0	12.0
Sundry labor expense	20.0	36.0
Auxiliary plants and services	15.0	15.0
General expense	15.0	15.0
TOTAL	160.0	207.0

Source: Lawrence Radiation Laboratory, *Nuclear Mining Feasibility Study.* UCRL-13104, Contract No. W-7405-eng-48 (1964).

Table I-5

COST OF CONVENTIONAL OPEN-PIT MINING

	Cost in cents per ton of solids mined
Drilling	0.5
Primary blasting	2.0
Secondary blasting	none
Shovel loading	2.0
Truck haulage	7.0
Road and dump maintenance	0.5
Supervisory, technical, and clerical wages	1.0
Service and miscellaneous expense	0.5
Miscellaneous pit expense	0.5
Equipment repairs	4.0
Sundry labor expense	3.0
General expense	2.0
TOTAL	23.0

Source: Lawrence Radiation Laboratory, *op. cit.*

Table I-6

AVERAGE COSTS IN PRODUCING ORE BY THE SQUARE-SET METHOD

	Costs per ton of ore
Labor	$4.62
Explosives	.33
Timber	.61
Miscellaneous supplies	1.10
Power	.41
Sundry	.15
Indirect	1.28
Depreciation	.23
TOTAL	$8.73

Source: *Engineering & Mining Journal* "Mineral Processing Costs – Interesting But Little Talked About," v. 162, n. 6, June 1961.

APPENDIX J

OUTPUT OF SELECTED MINERALS IN THE UNITED STATES

(Data Relevant to Chapter 9)

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Table J-1

ANNUAL U.S. MINE RECOVERABLE PRODUCTION OF PRECIOUS METALS

Year	Gold (Oz.)	Silver (Oz.)
1947	2,109,000	35,824,000
1948	2,014,000	38,096,000
1949	1,992,000	34,675,000
1950	2,394,000	42,459,000
1951	1,981,000	39,767,000
1952	1,893,000	39,452,000
1953	1,958,000	37,571,000
1954	1,837,000	36,941,000
1955	1,880,000	37,198,000
1956	1,832,000	38,948,000
1957	1,794,000	38,165,000
1958	1,739,000	34,111,000
1959	1,603,000	31,194,000
1960	1,667,000	30,766,000
1961	1,548,000	34,794,000
1962	1,543,000	36,798,000
1963	1,454,000	35,243,000
1964	1,456,000	36,334,000
1965	1,705,000	39,806,000
1966	1,803,000	43,669,000
1967	1,584,000	32,119,000

Source: *Minerals Yearbooks & Commodity Data Summaries*, 1968.

Table J-2

ANNUAL U.S. RECOVERABLE MINE PRODUCTION OF BASE METALS

Year	Iron Ore (long tons)	Copper (tons)	Lead (short tons)	Zinc (short tons)
1947	93,091,000	847,563	381,109	637,608
1948	101,003,000	843,813	390,476	629,977
1949	84,937,000	752,750	409,908	593,203
1950	98,045,000	909,343	430,827	623,375
1951	116,505,000	928,330	388,164	681,189
1952	97,918,000	925,359	390,162	666,001
1953	117,995,000	926,448	341,872	547,430
1954	78,094,000	835,472	325,427	473,471
1955	103,003,000	998,570	333,428	514,671
1956	97,877,000	1,104,156	349,188	542,340
1957	106,148,000	1,086,859	301,577	531,735
1958	67,709,000	979,329	250,570	412,005
1959	60,276,000	824,846	255,586	425,303
1960	88,784,000	1,080,169	246,669	435,427
1961	71,329,000	1,165,155	261,921	464,390
1962	71,829,000	1,228,421	236,956	505,491
1963	73,599,000	1,213,166	253,369	529,254
1964	84,836,000	1,246,780	286,010	574,858
1965	87,439,000	1,351,734	301,147	611,153
1966	90,147,000	1,429,151	327,368	572,555
1967	84,179,000	954,064	316,931	549,413

Source: *Minerals Yearbooks & Commodity Data Summaries*, 1968.

Table J-3

ANNUAL U.S. RECOVERABLE MINE PRODUCTION OF FERROALLY METALS

Year	Nickel (short tons) (Primary Plant Production)	Tungsten (lbs.) (Mine Shipments)	Molybdenum (lbs.) (Production of Concentrates)
1947	646	2,945,000	27,047,000
1948	883	3,838,000	26,706,000
1949	790	2,632,000	22,530,000
1950	913	4,588,000	28,480,000
1951	756	5,973,000	38,855,000
1952	633	7,244,000	43,259,000
1953	602	9,128,000	57,243,000
1954	2,645	13,030,000	58,668,000
1955	3,807	15,619,000	61,781,000
1956	6,722	14,027,000	57,462,000
1957	10,070	5,254,000	60,753,000
1958	11,740	3,605,000	41,069,000
1959	11,606	3,473,000	50,956,000
1960	14,303	6,972,000	68,237,000
1961	11,176	7,847,000	66,563,000
1962	11,217	8,021,000	51,244,000
1963	11,432	5,384,000	65,011,000
1964	12,185	8,798,000	65,605,000
1965	13,510	7,566,000	77,372,000
1966	13,237	8,842,000	90,532,000
1967	14,615	8,649,000	88,930,000

Source: *Minerals Yearbooks and Commodity Data Summaries*, 1968.

Table J-4

ANNUAL U.S. RECOVERABLE MINE PRODUCTION OF OTHER METALS

Year	Sodium (short tons)	Mercury (flasks)	Uranium (short tons) (mill production) (U_3O_8)	Beryllium (short tons)
1947	w	23,244	w	145
1948	w	14,388	w	99
1949	w	9,930	w	475
1950	w	4,535	w	559
1951	118,904	7,293	w	484
1952	123,187	12,547	w	515
1953	120,981	14,337	w	751
1954	126,887	18,543	w	669
1955	114,700	18,955	w	500
1956	136,017	24,177	w	460
1957	132,977	33,380	8,640	521
1958	110,298	38,067	12,570	463
1959	112,019	31,256	16,420	328
1960	113,428	33,223	17,760	244
1961	109,100	31,662	17,399	317
1962	119,084	26,277	17,010	218
1963	125,566	19,117	14,218	w
1964	139,185	14,142	11,847	w
1965	151,588	19,582	10,442	w
1966	163,368	22,008	9,487	w
1967	163,448	23,784	8,425	w

Source: *Minerals Yearbooks* and *Commodity Data Summaries*, 1968.

w = withheld

Table J-5

ANNUAL U.S. PRODUCTION OF INDUSTRIAL MINERALS USED IN CONSTRUCTION

Year	Asbestos (Short Tons)	Stone (Short Tons) Limestone & Dolomite (Crushed & Broken Stone)
1947	25,139	213,497,000
1948	37,237	235,783,000
1949	42,918	231,602,000
1950	41,353	255,260,000
1951	51,730	286,275,000
1952	53,888	297,706,000
1953	57,950	310,313,000
1954	45,813	323,800,000
1955	44,752	362,196,000
1956	41,626	379,342,000
1957	42,967	384,294,000
1958	43,979	390,468,000
1959	45,459	433,003,000
1960	45,223	450,393,000
1961	52,814	437,398,000
1962	53,190	460,953,000
1963	66,396	488,348,000
1964	101,092	510,025,000
1965	118,275	554,034,000
1966	125,928	568,849,000
1967	123,189	568,902,000

Source: *Minerals Yearbooks & Commodity Data Summaries*, 1968

Table J-6

ANNUAL U.S. PRODUCTION OF OTHER INDUSTRIAL MINERALS

Year	Phosphate Rock (long tons) (Marketable Production)	Potash (short tons) (Marketable Salts)	Sodium Carbonate (short tons)	Sodium Sulphate (short tons)
1947	9,121,000	1,906,000	293,000	627,000
1948	9,388,000	2,138,000	289,000	656,000
1949	8,877,000	2,057,000	200,000	538,000
1950	11,114,000	2,243,000	351,000	561,000
1951	10,775,000	2,475,000	351,000	707,000
1952	12,031,000	2,866,000	323,000	662,000
1953	12,504,000	3,266,000	419,000	734,000
1954	13,821,000	3,322,000	527,000	663,000
1955	12,265,000	3,514,000	614,000	685,000
1956	15,747,000	3,679,000	653,000	726,000
1957	13,976,000	3,840,000	653,000	727,000
1958	14,879,000	3,640,000	629,000	664,000
1959	15,869,000	4,033,000	735,000	728,000
1960	17,516,000	4,472,000	809,000	750,000
1961	18,559,000	4,629,000	806,000	815,000
1962	19,382,000	4,167,000	978,000	826,000
1963	19,855,000	4,871,000	1,119,000	837,000
1964	22,960,000	4,954,000	1,275,000	926,000
1965	26,282,000	5,401,000	1,494,000	976,000
1966	34,861,000	5,701,000	1,738,000	1,009,000
1967	35,509,000	5,649,000	1,728,000	968,000

Source: *Minerals Yearbooks* and *Commodity Data Summaries*, 1968.

Table J-7

LIMESTONE, CRUSHED AND BROKEN, SOLD OR USED IN THE UNITED STATES, BY PRINCIPAL USES, 1951-52

	1951		1952	
Use	Short tons	Value	Short tons	Value
e and roadstone	112,717,000	$140,354,000	127,379,000	$163,581,000
d ballast	9,085,000	9,575,000	8,827,000	9,390,000
stone	39,930,000	45,622,000	34,909,000	41,119,000
ture	19,401,000	31,052,000	21,152,000	34,464,000
	3,101,000	4,043,000	4,872,000	6,424,000
works	7,709,000	7,207,000	6,558,000	6,448,000
carbide	889,000	904,000	723,000	762,000
ne dusting	385,000	1,523,000	422,000	1,685,000
	2,023,000	5,703,000	1,953,000	5,412,000
beds	193,000	306,000	89,000	146,000
actories	794,000	1,907,000	814,000	1,933,000
ne sand	800,000	962,000	1,698,000	2,158,000
ne whiting	710,000	6,702,000	762,000	7,165,000
lls	446,000	943,000	360,000	821,000
grit	99,000	524,000	79,000	604,000
ry (dolomite)	1,112,000	1,520,000	708,000	1,048,000
e	1,485,000	1,310,000	1,371,000	1,245,000
ctories	563,000	1,369,000	541,000	1,404,000
nd unspecified	3,231,000	7,822,000	3,251,000	8,054,000
al	204,673,000	$269,348,000	216,468,000	$293,863,000
	64,284,000	NA	64,305,000	NA
	16,511,000	NA	16,146,000	NA
and Total proximate)	285,468,000	NA	296,919,000	NA

a not available.

f Data: Oliver, Bowles, *Limestone & Dolomite*, 1956, USBM IC 7738, p. 12.

Table J-8

NUMBER AND PRODUCTION OF COMMERCIAL CRUSHED STONE PLANTS IN THE UNITED STATES, BY SIZE OF OPERATION 1947 AND 1967

Average Production in tons per day	1947 Number of Plants	1947 Percent	1967 Number of Plants	1967 Percent
Less than 83	595	37.2	1,013	30.3
83 to 167	251	15.7	363	10.9
167 to 250	189	11.8	226	6.8
250 to 333	118	7.4	213	6.4
333 to 667	205	12.8	508	15.2
667 to 1,000	98	6.1	266	8.0
1,000 to 1,333	54	3.4	216	6.5
1,333 to 1,667	23	1.4	131	3.9
1,667 to 2,000	18	1.1	98	2.9
2,000 to 2,333	15	.9	69	2.1
2,333 to 2,667	6	.4	60	1.8
2,667 to 3,000	3	.2	41	1.2
3,000 tons and over	26	1.6	134	4.0
TOTAL	1,601	100.0	3,338	100.0

Source of Data: U. S. Bureau of Mines, *Minerals Yearbook.*

APPENDIX K

VALUE OF INDUSTRIAL MINERALS PRODUCTION IN THE WESTERN UNITED STATES

(Data relevant to Chapters 9 and 11)

Table K-1

TOTAL DOLLAR VALUE OF NON-METALLIC NON-FUEL MINERALS PRODUCTION IN THE WESTERN STATES

(in thousands of dollars)

State	1951	1952	1953	1954	1955	1956	1957
Arizona	7.429	9.899	13.971	15.249	20.919	23.210	25.795
California	214.209	211.910	245.430	295.450	322.375	389.121	391.349
Colorado	47.074	57.340	67.995	83.466	82.381	93.990	101.493
Idaho	10.362	11.845	13.578	19.577	18.870	22.056	20.153
Montana	21.844	22.375	24.335	31.497	37.171	38.087	38.107
Nevada	10.374	10.630	12.129	20.200	23.771	25.278	24.429
New Mexico	42.814	50.889	63.370[b]	78.207[b]	82.413[b]	88.546[b]	93.400[b]
Oregon	27.918	26.278	24.009	33.117	32.490	34.755	42.615
Utah	29.318[a]	30.445[a]	35.918[a]	32.879[a]	36.791	45.305	56.286
Washington	34.439	35.261	34.339	40.364	50.129	44.966	48.693
Wyoming	16.188	20.207	30.337	29.716	35.616	33.932	33.888

[a] includes CO_2; [b] includes Helium

Source of Data: *Minerals Yearbook*, U. S. Department of the Interior, Bureau of Mines.

Table K-1 (continued)

TOTAL DOLLAR VALUE OF NON-METALLIC, NON-FUEL MINERALS PRODUCTION

State	1958	1959	1960	1961	1962	1963	1964	1965
Arizona	27.123	28.942	38.309	44.664	48.761	42.765	48.936[b]	39.615[b]
California	393.424	436.084	432.678	455.736	474.291	503.892	548.285	554.873
Colorado	87.797	105.238	57.687[a]	61.629[a]	62.350[a]	60.080[a]	51.334[a]	51.145[a]
Idaho	21.173	21.661	22.449	21.546	30.787	27.663	26.820	38.953
Montana	35.398	33.339	32.340	34.219	37.007	39.520	49.208	43.773
Nevada	15.858	21.481	19.499	24.052	24.789	26.121	31.422	31.702
New Mexico	87.300[b]	95.839[b]	101.901[b]	120.965[c]	108.232[c]	133.447[c]	134.645[c]	148.924[c]
Oregon	45.821	50.537	50.385	52.959	52.310	62.509	64.268	82.159
Utah	58.512[a]	42.810[a]	51.757[a]	72.836[a]	82.854[a]	61.648[a]	65.391[a]	74.645[a]
Washington	54.468	57.523	59.981	54.773	58.393	61.034	68.830	75.187[a]
Wyoming	34.008	31.376	37.153	40.121	42.889	47.098	49.365	55.158

[a] includes CO_2; [b] includes Helium; [c] includes both

Source of Data: *Minerals Yearbook*, U.S. Department of the Interior, Bureau of Mines.

Table K-2

TOTAL VALUE OF NON-METALLIC MINERAL PRODUCTION IN THE ELEVEN WESTERN STATES, 1949 and 1966

(in millions of dollars)

State	1949	1966
Washington	$ 25	$ 79
Arizona	32	45
Oregon	21	107
New Mexico	31	155
California	148	578
Montana	12	45
Nevada	7	32
Utah	22	77
Colorado	27	53
Idaho	7	45
Wyoming	12	62
TOTAL	$345	$1,278

Source of Data: *Minerals Yearbook,* various.

APPENDIX L

RELATIVE AMOUNTS OF SELECTED MINERAL COMMODITIES MINED BY DIFFERENT MINING METHODS

(Data relevant to Chapter 9)

Table L-1

PERCENT OF ORE MINED BY SURFACE METHODS IN THE UNITED STATES
(Precious Metals)

Year	Gold (percent)	Silver (percent)
1947	20	11
1948	19	10
1949	19	9
1950	22	11
1951	24	11
1952	25	10
1953	26	11
1954	22	10
1955	24	13
1956	25	12
1957	25	12
1958	20	12
1959	19	11
1960	27	17
1961	28	16
1962	28	16
1963	28	15
1964	24	17
1965	40	19
1966	44	19
1967	43	16
1970	37.83^{p}	19.05^{p}
1975	42.28^{p}	21.28^{p}
1980	46.72^{p}	23.51^{p}
1985	51.16^{p}	25.75^{p}

$\bar{\bar{Y}}_{Au}=.888x + 16.514$ $\bar{\bar{Y}}_{Ag}=.447x + 8.324$

σ =4.892 σ =1.480

p = Projection of existing trend.

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, the University of Arizona.

Table L-2

PERCENT OF ORE MINED BY SURFACE METHODS IN THE UNITED STATES

(Base Metals)

Year	Copper (percent)	Lead (percent)	Zinc (percent)	Iron (percent)
1947	73	0	0	75
1948	76	0	0	78
1949	78	0	0	75
1950	81	0	0	77
1951	84	0	0	79
1952	85	0	0	78
1953	83	0	0	79
1954	83	0	0	78
1955	83	0	0	81
1956	78	0	0	82
1957	77	0	0	81
1958	76	0	0	83
1959	79	0	0	85
1960	80	0	0	87
1961	80	0	0	88
1962	81	0	0	86
1963	81	0	0	94
1964	82	0	0	94
1965	84	0	0	90
1966	85	0	0	90
1967	86	0	0	92
1970	84.04^p	0	0	97.01^p
1975	85.32^p	0	0	101.98^p
1980	86.60^p	0	0	106.95^p
1985	87.88^p	0	0	111.91^p
	$\bar{\bar{Y}}_{cu}=.256x + 77.900$	$\bar{\bar{Y}}=0$	$\bar{\bar{Y}}=0$	$\bar{\bar{Y}}_{fe}=.994x + 73.157$
	$\sigma\ =3.081$	$\sigma=0$	$\sigma=0$	$\sigma\ =2.141$

p = Projection of existing trend.

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, the University of Arizona.

Table L-3

PERCENT OF ORE MINED BY SURFACE METHODS IN THE UNITED STATES
(Other Metals)

Year	Uranium (percent)	Molybdenum (percent)	Mercury (percent)	Nickel (percent)
1947		0	9	-
1948	1.31	0	11	-
1949	0.58	0	0	-
1950	12.15	0	0	-
1951	16.27	0	5	-
1952	21.02	0	3	-
1953	24.79	0	7	100
1954	26.29	0	3	100
1955	19.31	0	6	100
1956	37.89	0	3	100
1957	34.27	0	20	100
1958	38.57	0	26	100
1959	25.20	0	25	100
1960	28.41	0	25	100
1961	28.39	0	23	100
1962	25.37	0	17	100
1963	29.26	0	27	100
1964	24.25	0	30	100
1965	28.88	0	28	100
1966	31.43	19.3	22	100
1967	29.28	20.0	20	100
1970	38.57^p	22.1^p	32.25^p	100^p
1975	44.32^p	25.6^p	28.98^p	100^p
1980	50.08^p	29.1^p	45.71^p	100^p
1985	55.84^p	32.6^p	52.43^p	100^p
	$\bar{\bar{Y}}_U=1.152x + 12.056$ $\sigma = 7.627$	$\bar{\bar{Y}}_{Mo}=.700x + 18.6$ $\sigma = 0$	$\bar{\bar{Y}}_{Hg}=1.345x + (-.038)$ $\sigma = 6.238$	$\bar{\bar{Y}}_{Ni}=0x + 100$ $\sigma = 0$

^{p}= Projection of existing trend.

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research. The University of Arizona.

Year	Phosphates (percent by surface methods)	Potash (percent by underground methods)	Sulfur (percent by Frasch process)	Salt (percent by underground methods)
1947	98	84.09+	NA	23.38
1948	98	84.65+	NA	23.45
1949	98	82.94+	NA	22.24
1950	98	84.41+	86.73	23.61
1951	98	86.11+	85.17	23.07
1952	98	88.16+	84.22	23.36
1953	98	90.03+	82.51	21.54
1954	98	90.48+	83.57	23.34
1955	98	91.87+	81.67	23.31
1956	98	91.94+	82.93	23.22
1957	98	91.79+	79.64	22.39
1958	98	92.12+	75.64	24.67
1959	98	91.85+	75.22	24.48
1960	98	92.49+	74.21	25.37
1961	99	92.67+	76.36	25.04
1962	99	90.04+	73.76	26.81
1963	98	92.28+	73.47	27.23
1964	99	92.33+	73.71	27.04
1965	99	90.70+	74.48	28.08
1966	99	88.94+	76.49	27.47
1967	99	87.39+	76.77	29.77
1970	99.01^{p}	93.69^{p}	76.24^{p}	28.68^{p}
1975	99.29^{p}	95.34^{p}	75.17^{p}	30.21^{p}
1980	99.57^{p}	97.00^{p}	74.09^{p}	31.73^{p}
1985	99.85^{p}	98.65^{p}	73.01^{p}	33.26^{p}

$\bar{\bar{Y}}_{P_2O_5} = .056x + 97.671$ $\quad$ $\bar{\bar{Y}}_{K_2O} = .331x + 85.738$ $\quad$ $\bar{\bar{Y}}_{S} = -.216x + 80.770$ $\quad$ $\bar{\bar{Y}}_{NaCl} = .305x + 21.357$

$\sigma = .3870$ $\quad$ $\sigma = 2.49$ $\quad$ $\sigma = 3.60$ $\quad$ $\sigma = 1.12$

^{p} = Projection of existing trend.

Source of Data: U. S. Bureau of Mines for 1947-1967. Projections by Division of Economic and Business Research, the University of Arizona.

APPENDIX M

AVERAGE DOMESTIC PRICES FOR SELECTED MINERAL COMMODITIES

(Data relevant to Chapter 10)

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Table M-1

AVERAGE ANNUAL DOMESTIC PRICE OF PRECIOUS METALS

Year	Gold $/Troy Oz.	Silver ¢/Troy Oz.
1947	35.00	71.820
1948	35.00	74,361
1949	35.00	71.930
1950	35.00	74.169
1951	35.00	89.386
1952	35.00	84.941
1953	35.00	85.188
1954	35.00	85.250
1955	35.00	89.099
1956	35.00	90.826
1957	35.00	90.820
1958	35.00	89.044
1959	35.00	91.202
1960	35.00	91.375
1961	35.00	92.449
1962	35.00	108.521
1963	35.00	127.912
1964	35.00	129.300
1965	35.00	129.300
1966	35.00	129.300
1967	35.00	154.968

Source of Gold Prices: *Minerals Yearbooks* and 1968 *Commodity Data Summaries.*

Source of Silver Prices: *Engineering & Mining Journal,* Feb. 1967 & for the 1967 Price, *Commodity Data Summary 1968.*

Table M-2

AVERAGE ANNUAL DOMESTIC PRICE OF BASE METALS

Year	Iron ore ($/ton)	Copper (¢/lb.)	Lead (¢/lb.)	Zinc (¢/lb.)
1947	3.44	20.958	14.673	10.500
1948	3.91	22.038	18.040	13.589
1949	4.50	19.202	15.364	12.144
1950	4.99	21.235	13.296	13.866
1951	5.46	24.200	17.500	18.000
1952	6.09	24.200	16.467	16.215
1953	6.76	28.798	13.489	10.855
1954	6.99	29.694	14.054	10.661
1955	7.12	37.491	15.138	12.299
1956	7.76	41.818	16.013	13.494
1957	8.33	29.576	14.658	11.399
1958	8.59	25.764	12.109	10.309
1959	8.69	31.182	12.211	11.448
1960	8.73	32.053	11.948	12.946
1961	8.99	29.921	10.871	11.542
1962	8.84	30.600	9.631	11.625
1963	9.22	30.600	11.137	11.997
1964	9.52	31.960	13.596	13.568
1965	9.53	35.017	16.000	14.500
1966	9.49	36.170	15.115	14.500
1967	9.92	38.226	14.000	13.843

Sources of Data: *Engineering & Mining Journal*, Feb. 1967 issue; 1967 price source: *Commodity Data Summaries* 1968. *Minerals Yearbook* for iron ore prices.

Table M-3

AVERAGE ANNUAL DOMESTIC PRICE OF FERROALLOY METALS

Year	Nickel[a] (¢/lb.)	Tungsten ($/unit Wo_3)	Molybdenum[b] ($/lb. contained m
1947	35.000	23.43	.75
1948	36.350	26.27	.75
1949	40.000	26.38	.90
1950	44.770	28.25	.90
1951	54.000	61.02	1.00
1952	56.500	63.44	1.00
1953	59.850	62.46	1.00
1954	60.375	62.61	1.00
1955	64.500	61.79	1.05
1956	65.290	57.90	1.13
1957	74.000	24.72	1.18
1958	74.000	17.56	1.19
1959	74.000	20.56	1.25
1960	74.000	22.33	1.25
1961	77.625	21.36	1.32
1962	79.940	23.02	1.40
1963	79.000	21.22	1.40
1964	79.000	20.28	1.55
1965	78.690	27.32	1.55
1966	79.000	32.95	1.55
1967	87.800	38.32	1.62

[a] Weighted average due to price changes during year, price includes duty of 21/2¢ in 1947, 11/4¢ from 1948 to September 1965.

[b] Weighted average due to price changes within year. 1947-1954 figures of $/lb. MoS_2 have been converted to $/lb. contained moly. where $.60/lb. = $1.00 /lb. contained molybdenum.

Sources: *Minerals Yearbook*
Commodity Data Summaries, 1968

Table M-4

AVERAGE ANNUAL DOMESTIC PRICES OF MISCELLANEOUS METALS

Year	Sodium[a] ($/lb.)	Mercury ($/76 lb. flock)	Uranium[b] ($/lb. U_3O_8)	Beryllium[c] ($/unit BeO imported)
1947	.15	83.74	-	14.95
1948	.1575	76.49	-	17.41
1949	.165	76.46	-	22.52
1950	.16	81.26	-	25.43
1951	.16	210.13	-	31.67
1952	.165	199.097	-	38.55
1953	.165	193.032	-	47.00
1954	.16	264.386	-	43.00
1955	.16	290.348	-	37.00
1956	.16	259.923	-	36.00
1957	.17	246.978	4.20	32.00
1958	.17	229.057	4.15	31.00
1959	.17	227.484	4.07	27.00
1960	.17	210.760	4.02	29.00
1961	.17	197.605	4.00	30.00
1962	.17	191.208	4.05	31.00
1963	.17	189.451	4.05	24.00
1964	.17	314.787	4.08	23.00
1965	.17	570.747	4.04	24.00
1966	.17	441.719	3.90	25.00
1967	.18	489.355	3.90	30.00

[a] Bulk, tanks, works in $/lb. (prior to 1954 quoted as drums, carlots, works)

[b] Unit price = total value of domestic ore shipped divided by lbs. of U_3O_8 shipped

[c] Price approximate, per unit BeO imported, cobbed beryl at part of exportation

Source of Mercury Prices: *Engineering & Mining Journal*, February, 1967
Sources of Other Metals: *Metals Yearbook*
All 1967 prices from *Commodity Data Summaries*, 1968

Table M-5

AVERAGE ANNUAL DOMESTIC PRICES OF INDUSTRIAL MINERALS USED IN CONSTRUCTION

Year	Asbestos[a] ($/short ton)	Lime[b] ($/ton)	Cement[c] ($/barrel)
1947	38.24	9.42	1.90
1948	48.69	10.35	2.18
1949	60.25	10.97	2.30
1950	68.93	11.13	2.35
1951	75.75	11.74	2.55
1952	87.50	11.80	2.54
1953	89.19	11.59	2.68
1954	98.65	11.79	2.78
1955	100.65	12.13	2.89
1956	114.79	12.83	3.08
1957	112.66	13.17	3.21
1958	116.58	12.84	3.27
1959	96.61	13.13	3.30
1960	93.56	13.35	3.39
1961	82.31	13.83	3.36
1962	87.93	13.58	3.31
1963	76.93	13.73	3.23
1964	80.55	13.87	3.22
1965	85.92	13.87	3.18
1966	87.80	13.27	3.15
1967	90.12	13.42	3.17

[a] $ value/short ton of U. S. production (sold or used)

[b] average $ value/ton (of quick lime, hydrated lime, dead burned dolomite)

[c] average $ value/barrel

Sources: *Minerals Yearbooks* and *Commodity Data Summaries* 1968.

Table M-6

AVERAGE ANNUAL DOMESTIC PRICES OF OTHER INDUSTRIAL MINERALS

Year	Phosphate Rock[a] ($/ton)	Potash[b] ($/ton)	Sodium Carbonate[c] ($/cwt) Soda Ash	Sodium Sulphate[d] ($/ton) 100% Na_2SO_4
1947	5.22	17.77	1.25	19.00
1948	5.83	16.75	1.35	26.50
1949	5.72	17.02	1.40	25.00
1950	5.76	17.87	1.075	19.58
1951	5.96	18.27	1.20	17.00
1952	6.01	19.50	1.50	17.00
1953	6.13	20.10	1.60	18.17
1954	6.27	21.96	1.65	21.58
1955	6.15	22.51	1.675	27.67
1956	6.22	22.33	1.775	28.00
1957	6.27	21.97	1.85	28.00
1958	6.30	20.64	1.85	31.00
1959	6.22	20.02	1.85	28.00
1960	6.68	19.37	1.85	28.00
1961	7.03	22.57	1.85	28.00
1962	6.93	22.89	1.85	28.00
1963	7.04	22.64	1.85	28.00
1964	7.02	23.13	1.85	28.00
1965	7.36	24.10	1.85	28.00
1966	7.49	21.64	2.00	28.00
1967	7.72	18.75	1.95	28.00

[a] $ value/tons of marketable production

[b] $ value/sales of potassium salts by quantity (tons)

[c] Light, bags, carlots, works in $/cwt (weighted average prior to 1957)

[d] Domestic Salt Cake, bulk, works in $/ton (weighted average prior to 1956)

Source: *Minerals Yearbooks* and *Commodity Data Summaries 1968*.

APPENDIX N

THE PERSONAL INCOME MULTIPLIER, ESTIMATES FOR EACH OF THE 11 WESTERN STATES

(Relevant to Chapter 11)

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THE INCOME MULTIPLIERS OF THE ELEVEN WESTERN STATES

The calculation of the multipliers applicable to the 11 Western States could best be described, perhaps, as an intuitively plausible approach to an econometric problem. In lieu of an econometric model, an iterative quantification attempt was made which can be described as follows.

Assume first an increment of $100 in personal income. Of this income there will be some "leakage" in the form of payroll taxes and savings, but most will be spent on consumers goods and services. The fraction which is spent is usually referred to as the "marginal propensity to consume," and this accounts for the transformation of the greater share of the $100 increment of personal income into business income. This process represents the first round or stage of the multiplier.

In the second and successive stages, the multiplier effects are all similar in nature. The initial increase in income is spread through the economy as the resultant spending leads to increases in others' incomes and still more spending until the leakages of successive periods reduce the stream to insignificant dimensions. Thus, of the second stage's new business income, some becomes leakage and some is transformed into new personal incomes at a rate depending on the ratio of payrolls to sales in the particular industries in question. The new business income also becomes additional business income in later periods, for the initial recipients of the increased spending carry on transactions with and generate new income for other related industries. In short, the business income of one round (minus the personal income it generates and the leakage experienced in the process) becomes the business income of the next round. The personal income of one round (minus leakage) becomes the business income of the next round. The process continues until the incremental income becomes miniscule.

The reasoning and methodology can be illustrated by a look at one of the multiplier derivations. The Arizona case can serve as an illustration of the process, which was applied to all 11 states. The income generating industries are listed under "Item." The personal income derived from each industry is given in column (1) and the percentage of the total that each represents is listed in column (2). Column (3) deals with first round leakage (other than payroll taxes and savings which are merely deducted) in the form of a "factor" designed to account for out-of-state taxes. Column (4) is the result of applying (3) to (2), and shows the amount of first stage spending that becomes business income. Column (5) shows the factor to be applied to each industry to derive the amount of business income transformed into the second stage into new personal income, the rate being determined by the ratio of payrolls to sales in the relevant industries. The magnitude of the transformation of business into personal income is given in column (6), which is the product of columns (4) and (5). Proprietors' incomes and property incomes are included in the total of column (6).

Column (7) gives the second round leakage factor, which is designed to account for leakages in the form of federal taxes and out-of-state wholesale purchases. When this factor is applied by multiplying columns (4) and (7), the magnitude of the leakage is known for each of the relevant industries, the summation of which gives total leakage for the second stage. Once stage two's personal income and leakage have been calculated, the business income of the following stage is known. It is simply the business income of the previous round minus personal income and leakage of the present round. The process is repeated in following time periods until the diminishing effects are completely exhausted. Each time period is roughly equivalent to two weeks.

Table N-1

DERIVATION OF THE PERSONAL INCOME MULTIPLIER FOR ARIZONA

	P.I. (Amt) Western Region	P.I. (%)	P.I. to B.I. (Factor)[a]	P.I. to B.I. B.I. 1st stage	B.I. to P.I. (Factor)	B.I. to P.I. P.I. 2nd stage	B.I. to L. (Factor)[b]	B.I. to L. L. 2nd stage	B.I. to B.I. B.I. 2nd stage
A Money income before taxes	(1) 7040	100.0	--	--	--	--	--	--	
1. Payroll taxes	784	11.1	.02	.22	--	--	--	--	
B Money income after taxes	6256	88.9	--	--	--	--	--	--	
2. Personal insurance	321	4.6	.20	.92	.50	.46	--	--	
3. Net income in assets (savings)	185	2.6	--	--	--	--	--	--	
4. Gifts & contributions	125	1.8	1.00	1.80	1.00	1.80	--	--	
C Expenditures per current consumption	5625	79.9	--	--	--	--	--	--	
5. Food at home	1047	14.9	1.00	14.90	(2) .08	1.19	.20	2.98	
6. Food away from home	288	4.1	97	3.98	(2) .27	1.07	.05	.20	
7. Tobacco	85	1.2	1.00	1.20	.13	.16	.05	.06	
8. Alcoholic beverages	100	1.4	1.00	1.40	(2) .13	.18	.05	.07	
9. Shelter	751	10.6	1.00	10.60	.07	.74	--	--	
10. Utilities	299	3.3	1.00	3.30	(4) .08	.26	.25	.83	
11. Household operations	319	4.5	1.00	4.30	.08	.36	.20	.90	
12. House furnishings & equipment	289	4.1	1.00	4.10	(2) .14	.57	.20	.82	
13. Clothing & services	549	7.8	1.00	7.80	(2) .13	1.01	.20	1.56	
14. Personal care	155	2.2	1.00	2.20	(3) .38	.84	--	--	
15. Medical care	401	5.7	1.00	5.70	.50	2.85	.04	.23	
16. Recreation	257	3.7	.98	3.63	(3) .28	1.02	.05	.18	
17. Reading	47	0.7	1.00	.70	(2) .18	.13	.10	.07	
18. Education	54	0.8	1.00	.80	.50	.40	--	--	
19. Auto transport	832	11.7	.95	11.12	(2) .10	1.11	.25	2.78	
20. Other transport	94	1.3	1.00	1.30	.10	.13	.25	.33	
21. Other expenditures	137	1.9	.90	1.71	(2) .13	.22	.15	.26	
				81.88		14.50 wages & salaries		11.26	51.09
						(6) 2.10 proprietor income			
						(6) 2.93 property income			
						19.53			

P.I. = Personal Income
B.I. = Business Income

a - All figures in column 3 are arbitrary except (1)
b - All figures in column 7 taken from leakage factor sheet

Sources of Data:
(1) BLS Survey of Consumer Expenditures, 1960-61 (total Western Region) page 11
(2) 1963 Census of Business (Retail Trade, Arizona) (wages/sales) Sic Code, page 4-6 to 4-7
(3) 1963 Census of Business (Selected Services, Arizona) (wages/sales) Sic Code, page 4-6 to 4-7
(4) Federal Power Commission (Statistics of Privately Owned Electric Utilities in the U.S.). Pages 101 & 104a
(5) Minimum State Tax Rate for Individuals
(6) Survey of Current Business (Aug., 1968, P. 19, Table 50) % of wages and salaries

APPENDIX O

VALUE ADDED BY MANUFACTURING AND CONSTRUCTION ACTIVITIES IN THE WESTERN STATES

(Data relevant to Chapter 11)

Table O-1

TOTAL VALUE ADDED BY MANUFACTURING IN THE WESTERN STATES

(in thousands of dollars)

Year	Arizona	California	Colorado	Idaho	Montana	Nevada	N. Mexico
1949	91,681	4,168,034	278,626	91,702	82,180	19,204	51,694
1950	127,946	5,120,976	340,795	118,675	107,837	28,670	102,897
1951	156,762	6,133,387	393,899	147,853	149,776	27,373	121,633
1952	159,753	6,960,932	397,464	142,553	138,952	31,889	128,211
1953	231,128	8,153,142	438,466	166,904	142,045	67,306	129,248
1954	192,497	8,597,453	472,433	182,276	141,234	62,672	126,326
1955	233,616	9,608,126	586,720	197,686	207,701	82,561	119,137
1956	287,614	11,181,066	679,640	217,954	257,016	105,319	133,965
1957	336,275	11,996,657	680,983	212,192	202,479	92,172	166,820
1958	360,173	12,047,983	781,943	255,258	196,915	67,591	114,897
1959	402,101	13,501,399	858,351	280,373	217,985	66,632	118,627
1960	459,137	13,857,442	935,401	265,997	203,894	71,894	122,856
1961	473,015	14,243,531	984,061	280,105	212,621	92,604	118,049
1962	501,924	15,868,371	1,151,831	297,256	229,148	99,116	136,340
1963	617,000	17,157,000	1,203,000	366,000	235,000	112,000	170,000
1964	654,321	18,016,941	1,152,708	406,446	273,841	113,768	150,226
1965	719,882	18,858,322	1,195,771	436,362	284,809	106,897	141,627
1966	926,452	21,331,103,	1,457,914	494,175	304,189	114,242	148,116

Note: Value added is the value of products shipped less the cost of materials, supplies, fuel, electrical energy, and contract work.

Source: *Annual Survey of Manufacturers,* U.S. Department of Commerce.

Table O-1 (Continued)

Year	Oregon	Utah	Washington	Wyoming
1949	633,136	138,268	926,630	29,513
1950	806,947	177,504	1,113,362	37,739
1951	945,875	223,221	1,343,983	37,245
1952	1,049,151	229,876	1,430,317	38,094
1953	985,834	272,449	1,482,007	54,099
1954	1,037,456	276,343	1,549,060	51,361
1955	1,149,896	386,311	1,761,803	50,648
1956	1,209,042	457,394	1,997,542	60,220
1957	1,061,734	473,514	2,123,411	61,258
1958	1,222,224	411,785	2,166,632	62,558
1959	1,441,496	457,045	2,343,415	71,555
1960	1,345,407	544,644	2,206,046	72,662
1961	1,336,978	631,485	2,463,892	69,839
1962	1,469,511	685,317	2,822,813	76,525
1963	1,570,000	705,000	2,873,000	83,000
1964	1,698,854	667,955	3,175,704	80,462
1965	1,833,324	683,163	3,179,104	93,882
1966	1,922,308	699,388	3,289,275	93,213

Table O-2

VALUATION OF CONSTRUCTION CONTRACTS BY STATES

(in thousands of dollars)

States	1956	1957	1958	1959	1960	1961
Arizona	311.262	484.717	413.524	459.271	453.381	549.597
California	4,058.692	4,023.750	4,367.607	4,875.351	4,946.589	5,249.304
Colorado	594.451	465.829	477.922	510.239	460.733	549.789
Idaho	108.771	138.672	150.750	122.241	115.442	142.298
Montana	213.965	139.069	161.864	134.113	133.438	194.616
Nevada	87.391	85.171	102.260	98.962	129.828	189.893
New Mexico	187.426	255.958	299.155	264.129	220.320	198.906
Oregon	298.484	298.944	383.690	353.943	364.592	415.011
Utah	191.421	226.648	268.049	227.104	194.722	262.228
Washington	798.909	685.750	672.937	830.870	632.291	679.182
Wyoming	133.714	107.224	106.426	108.868	121.234	110.927

Source of Data: *Construction Contracts*, F. W. Dodge Corporation, as quoted in the *Statistical Abstract of the United States*, various issues.

Table O-2 (continued)

VALUATION OF CONSTRUCTION CONTRACTS BY STATES
(figures include
non-residential, residential, and nonbuilding construction)

(in thousands of dollars)

States	1962	1963	1964	1965	1966
Arizona	477.089	466.668	459.861	412.680	462.965
California	5,729.540	6,989.488	6,588.462	6,333.451	5,598.525
Colorado	667.108	684.086	675.905	584.624	582.657
Idaho	155.513	138.816	173.540	186.753	250.647
Montana	192.543	153.962	185.655	218.572	220.409
Nevada	324.464	363.120	290.530	231.652	139.343
New Mexico	241.973	311.715	322.484	376.513	422.260
Oregon	449.526	574.034	496.593	585.700	535.357
Utah	275.097	333.768	269.294	240.017	210.559
Washington	808.532	891.070	832.616	1,006.742	1,021.358
Wyoming	91.735	141.201	143.183	117.224	132.142

Source of Data: *Construction Contracts,* F. W. Dodge Corporation, as quoted in the *Statistical Abstract of the United States,* various issues.

APPENDIX P

MINING AND PUBLIC FINANCE IN SELECTED WESTERN STATES

(Data relevant to Chapter 11)

Table P-1
MINING AND PUBLIC FINANCE IN ARIZONA

Revenue	1965	1966	1967
Property Tax[a]	$14,450,650.11	$15,117,690.21	$26,888,306.36
Net Income Tax[b]	$13,225,200.00	$14,038,200.00	$11,297,100.00
Severance Tax[c]	$ 5,193,956.83	$ 5,484,079.23	$ 4,290,936.03
Supplemental Severance Tax (50% of Severance Tax)	$ 2,596,978.42	$ 2,742,039.62	$ 2,145,468.02
Payroll Tax[d]	$ 1,045,400.87	$ 1,215,146.16	$ 1,317,740.54
License Tax[e]			
Oil & Gas Commission	$ 850.00	$ 900.00	$ 1,575.00
Royalties or Rentals from Fed. Gov't.	$ 937,252.78	$ 67,701.95	$ 105,207.79
Total Revenue (Mining)	$37,450,289.01	$38,665,757.17	$46,046,333.74
Expenditures			
Budgets of Regulatory Agencies			
State Mine Inspector[e]	$ 72,418.68	$ 71,642.01	$ 73,594.93
Copper Tariff Board[e]	——	400.00	49.65
Oil & Gas Commission[e]	50,535.00	51,049.93	49,030.72
Budgets of Research Agencies			
Dept. of Mineral Resources[e]	$ 85,529.00	$ 83,400.71	$ 82,912.91
Total Expenditures (Mining)	$ 208,482.68	$ 206,492.65	$ 205,588.21
Net Proceeds	$37,241,796.33	$38,459,264.52	$45,840,745.53

SOURCES: [a] *28th Biennial Report of the State Tax Commission of Arizona*, FYE, 1965-1967, p. 35 & 124.

[b] Wage Payments to Covered Employees in Arizona, *Arizona Statistical Review*, Valley National Bank, Sept. 1968, p. 16. Income Tax Rate-Lower bracket rate of 1%, *Retail Sales and Individual Income Taxes in State Tax Structures*, Tax Foundation Inc., Jan. 1962, p. 42, calendar year.

[c] *Computation of Tax Business Conducted in Arizona*, Arizona State Tax Commission, Privilege Sales Tax Division, calendar year.

[d] *Employment Security Commission of Arizona Fiscal Report*, FYE, 1965-1967, p. 43 & 51.

[e] *Arizona State Auditor Report*, FYE, 1965-1967, p. 10 & 25.

Table P-2

MINING AND PUBLIC FINANCE IN CALIFORNIA

Revenue	**1965**	**1966**	**1967**
Net Income Tax[a]			
Crude Pet. & Nat. Gas Prod.	$13,362,464.00	$16,107,143.00	
Other Mining & Quarrying	1,003,209.00	1,060,106.00	
Mfg. of Pet. & Coal Prod.	1,036,850.00	2,435,586.00	
Mfg. of Primary Metals	5,251,769.00	7,588,451.00	
Total Net Income Tax	$20,654,292.00	$27,191,286.00	
Payroll Tax	NA	NA	NA
License Tax	NA	NA	NA
Royalties or Rentals from Fed. Gov't.[b]			
Oil Revenue from Tidelands	9,231,575.00	$20,228,062.00	$13,785,921.00
Oil, Gas, and Minerals from other state lands	20,169,282.00	17,898,714.00	22,573,120.00
Oil, Gas, and Minerals from federal lands	2,646,290.00	2,315,740.00	2,689,102.00
Bid Bonuses on Oil Leases	39,108,011.00	7,349,334.00	2,819,879.00
Total Royalties	$71,155,158.00	$47,791,850.00	$41,868,022.00
Severance Tax[c]			
Petroleum & Gas	$ 693,000.00	$ 1,043,000.00	$ 1,103,000.00
Total Revenue (Mining)	$92,772,450.00	$76,026,136.00	$42,971,022.00

SOURCES: [a] *Annual Report - Franchise Tax Board*, State of California, 1966-1967, pp. 77-86
[b] *Annual Report of the State Controller*, FYE, June 30, 1965-1967, p. A-18.
[c] *State Tax Collections in 1965-1968*, U.S. Department of Commerce, Bureau of the Census.

Table P-3

MINING AND PUBLIC FINANCE IN COLORADO

Revenues	**1965**	**1966**	**1967**
Property Tax	NA	NA	NA
Net Income Tax	NA	NA	NA
Gross Income or Production Tax			
Gas & Oil[a]	$ 967,765.00	$ 1,015,859.00	$ 952,212.00
Sales Tax[a]			
Metal Products	$ 679,000.00	$ 1,109,000.00	$ 1,085,000.00
Minerals, Coal Mines, Assay Offices	17,000.00	29,000.00	32,000.00
Total Sales Tax	$ 696,000.00	$ 1,138,000.00	$ 1,117,000.00
Payroll Tax	NA	NA	NA
License Tax	NA	NA	NA
Severance Tax[b]			
Oil & Gas Production Gross Income	$ 1,114,000.00	$ 891,000.00	$ 970,000.00
Oil & Gas Conservation	103,000,00	101,000.00	104,000.00
Coal Tonnage	33,000.00	35,000.00	37,000.00
Total Severance Tax	$ 1,250,000.00	$ 1,027,000.00	$ 1,111,000.00
Royalties or Rentals from Fed. Gov't.[c]			
Oil & Gas Leases	$ 1,134,333.55	$ 998,134.27	$ 1,095,968.39
Metal & Misc. Mining Leases	37,557.18	46,516.68	99,194.39
Coal Leases	52,634.90	44,930.39	41,470.84
Total Royalties & Rentals	$ 1,224,525.63	$ 1,089,581.34	$ 1,236,633.62
Total Revenue (Mining)	$ 4,138,290.63	$ 4,270,440.34	$ 4,416,845.62

SOURCES: [a] *Annual Report of the Colorado Department of Revenue*, FYE, June 30, 1965-1967.
[b] *State Tax Collections in 1965-1968,* U.S. Dept. of Commerce-Bureau of the Census.
[c] *State Board of Land Commissioners of Colorado*, Fiscal Year July 1, 1966 - June 30, 1967, pp. 13-15.

Table P-4

MINING AND PUBLIC FINANCE IN IDAHO

Revenue	**1965**	**1966**	**1967**
Property Tax[a]	$ 64,809.31	$ 59,982.40	$ 63,826.04
Net Income Tax[b]	$ 610,948.14	$ 750,553.26	$ 273,968.89
Sales Tax[b]			
Metal Mining		$ 40,083.93	$ 46,506.41
Crude Petroleum & Nat. Gas Prod.		40,095.99	75,318.05
Non-Metallic Mining & Quarrying		2,029.52	3,203,26
Primary Metal Products		34,430.89	36,232.63
Fabricated Metal Products		73,533.40	104,974.79
Total Sales Tax		$ 190,173.73	$ 266,235.14
Payroll Tax	NA	NA	NA
License Tax[b]			
Mine License Tax	$ 173,737.47	$ 236,022.81	$ 199,261.93
Severance Tax[c]			
Mining Privilege	$ 174,000.00	$ 236,000.00	$ 199,000.00
Total Revenue (Mining)	$ 1,023,494.92	$ 1,472,732.20	$ 1,002,292.00

SOURCES: [a] *Annual Report of the State Tax Commission State of Idaho*, p. 16 & 42, 1965-1967.

[b] *19th Annual Report of Tax Collections of the State Tax Commission*, FYE June 30, 1967, pp. 4, 6, 7, 13.

[c] *State Tax Collections in 1965-1968*, U.S. Dept. of Commerce, Bureau of the Census.

Table P-5

MINING AND PUBLIC FINANCE IN MONTANA

Revenue	1965	1966	1967
Property Tax	NA	NA	NA
Net Income Tax	NA	NA	NA
Gross Income or Production Tax			
Oil[a]	$ 1,807,887.35	$ 2,059,211.15	$ 2,063,190.56
Sales Tax	— —	— —	— —
License Tax[a]			
Cement Dealers & Mfg.	$ 102,995.00	$ 94,634.00	$ 123,745.00
Coal Dealers & Miners	13,576.00	13,087.00	14,126.00
Oil Production	1,793,144.00	1,985,386.00	2,105,955.00
Metal Mines	905,207.00	1,135,743.00	1,200,734.00
Natural Gas	288,186.00	298,780.00	296,855.00
Vermiculite	6,824.00	8,163.00	8,481.00
Total License Tax	$ 3,109,932.00	$ 3,535,793.00	$ 3,749,896.00
Severance Tax[b]			
Oil Production	$ 1,960,000.00	$ 2,175,000.00	$ 2,292,000.00
Metal Mines	905,000.00	1,136,000.00	1,201,000.00
Coal Production	14,000.00	13,000.00	14,000.00
Vermiculite	7,000.00	8,000.00	8,000.00
Total Severance Tax	$ 2,886,000.00	$ 3,332,000.00	$ 3,515,000.00
Payroll Tax[c]			
Metal	$ 154,071.00	$ 169,496.00	$ 169,021.00
Coal	8,028.00	13,250.00	6,721.00
Crude Oil & Gas	114,933.00	110,786.00	88,776.00
Quarrying & Non-Metallic	43,908.00	42,511.00	40,787.00
Total Payroll Tax	$ 320,740.00	$ 336,043.00	$ 305,305.00
Total Revenue Mining	$ 8,124,559.35	$ 9,273,047.15	$ 9,633,391.56

SOURCES: [a] *Montana State Board of Equalization*, 22nd & 23rd Biennial Report, July 1, 1964 - June 30 1966 & July 1, 1966 - June 30, 1968.

[b] *State Tax Collections in 1965-1968*, U.S. Dept. of Commerce - Bureau of the Census.

[c] *32nd Annual Report on Employment Security in Montana*, FYE, June 30, 1965 - 1967, p. 27, Unemployment Compensation Commission.

Table P-6

MINING AND PUBLIC FINANCE IN NEW MEXICO

Revenue	1965	1966	1967
Severance Tax[a]	$10,913,344.00	$11,303,674.00	$12,183,788.00
Sales Tax 7% Oil Conservation[a]	$ 39,274.00	$ 40,681.00	$ 43,219.00
Royalties or Rentals from Fed. Gov't. Mineral Leasing[a]	$10,102,974.00	$11,184,721.00	$11,867,898.00
Property Tax	NA	NA	NA
Net Income Tax	NA	NA	NA
Payroll Tax	NA	NA	NA
License Tax	NA	NA	NA
Total Revenue (Mining)	$21,055,592.00	$22,529,076.00	$24,094,905.00
Expenditures			
Budgets of Regulatory Agencies			
Oil & Gas Central Acct. Comm.[a]	$ 209,022.86	$ 222,821.55	$ 257,191.45
State Mine Inspector[a]	105,577.16	110,162.05	119,650.01
Oil Conservation Comm.[a]	495,290.53	512,934.65	516,684.57
Budgets of Research Agencies			
Institute of Mining & Tech.[a]	$ 1,038,125.00	$ 1,280,000.00	$ 1,381,000.00
Miners Hospital[a]	552,590.17	578,876.19	642,798.44
Total Expenditures (Mining)	$ 2,400,605.72	$ 2,704,794.44	$ 2,917,324.47
Net Proceeds	$18,654,986.28	$19,824,281.56	$21,177,580.53

Sources: [a]*Annual Financial Report*, FYE, June 30, 1965-1967.

Table P-7

MINING AND PUBLIC FINANCE IN UTAH

Revenue	1965	1966	1967
Property Tax[a]			
Mining	$13,637,122.00	NA	NA
Oil & Gas	2,766,037.00	NA	NA
Total Property Tax	$16,403,159.00		
Payroll Tax	NA	NA	NA
Severance Tax[b]			
Mine Occupation	$ 1,739,000.00	$ 2,145,000.00	$ 2,105,000.
Oil & Gas Production	1,379,000.00	1,245,000.00	1,166,000.
Total Severance Tax	$ 3,118,000.00	$ 3,390,000.00	$ 3,271,000.
Net Income Tax	NA	NA	NA
Total Revenue (Mining)	$19,521,159.00	$ 3,390,000.00[+]	$ 3,271,000.

Sources: [a] *18th biennial report of the utah state tax commission,* FYE, 1965 & 1966 p. 36.

[b] *State Tax Collections in 1965-1967,* U. S. Dept. of Commerce, Bureau of the Census.

APPENDIX Q

EXPORTS OF NONFUEL MINERALS FROM THE WEST AND TO PACIFIC BASIN COUNTRIES

(Data relevant to Chapter 11)

Table Q-1

EXPORT OF NONFUEL MINERALS FROM WESTERN STATES, 1960-1966

(Millions of Dollars)

State	Primary Metal Products				Stone, Clay and Glass			
	1960	1963	1966	% of U.S. X's, '66	1960	1963	1966	% of U.S. X's, '66
Arizona	N/A	(U)	(U)	N/A	-	-	-	-
California	46.6	31.9	43.4	4.0	4.6	5.0	9.3	3.3
Colorado	14.5	9.1	7.2	0.7	N/A	0.2	1.4	0.5
Idaho	N/A	(S)	(S)	N/A	-	-	-	-
Montana	N/A	(V)	(U)	N/A	N/A	0.2	1.2	0.4
Nevada	N/A	(T)	(U)	N/A	N/A	(S)	(S)	N/A
New Mexico	N/A	(V)	(V)	N/A	-	-	-	-
Oregon	6.0	6.2	12.5	1.2	N/A	0.5	0.8	0.3
Utah	N/A	(V)	(V)	*	N/A	0.3	1.1	0.4
Washington	52.5	53.6	58.1	5.4	(S)	0.3	0.4	0.1
Wyoming	N/A	(S)	(S)	N/A	-	-	-	-

N/A = not available
(S) = less than $1.0 million
(T) = $1.0 to $4.9 million
(U) = $5.0 to $9.9 million
(V) = $10.0 to $24.9 million
* = between 0.9 and 2.3 percent

Source: U. S. Department of Commerce

Table Q-2

U.S. EXPORT OF METALS TO JAPAN 1960-1964 (Thousands of Dollars)

	1960	1961	1962	1963	1964
Metalliferous Ores and Metal Scrap	187,056	308,860	110,930	161,727	203,309
Iron Ores and Concentrates	8,623	9,655	10,213	17,086	20,247
Iron and Steel Scrap	115,680	224,926	76,333	109,514	120,466
Ores and Concentrates of Non-ferrous base metals	9,817	10,846	4,115	7,392	10,120
Molybdenum Ore and Concentrate	7,020	9,057	3,149	6,500	9,060
Non-ferrous Metal Scrap	52,414	63,079	20,241	27,703	52,395
Aluminum and Aluminum Base Alloy Scrap	5,696	8,932	3,673	4,697	5,248
Copper and Copper Base Alloy Scrap	43,697	51,564	15,072	17,244	38,459
Nickel and Nickel Base Alloy Scrap	2,355	2,089	1,421	5,751	8,218

Source: *U.S. Trade with Japan:* 1960-1964, U.S.-Japan Trade Council.

Table Q-3

JAPANESE PRODUCTION AND IMPORTS OF REFINED NONFERROUS METALS, 1964-1965

(Thousand Metric Tons)

	Domestic Production (1964)	Imports (1964)	Domestic Production (1965)	Imports (1965)
Copper	342	122	366	115
Lead	108	68	109	38
Zinc	316	69	368	7
Tin	2	16	-2	15
Nickel	7	3	6	3
Aluminum	264	66	292	42

Source: *Basic Data on the Economy of Japan, Overseas Business Reports,* U.S. Department of Commerce.

Table Q-4

JAPANESE PRODUCTION AND IMPORTS OF ORES
1964-1965

(Thousand Metric Tons)

	1964		1965	
	Domestic Production	Imports	Domestic Production	Imports
Iron Ore	1,132	31,236	1,119	39,018
Copper Ore	106	161	107	N/A
Zinc Ore	216	144	221	380
Lead Ore	54	30	N/A	67

Source: *Basic Data on the Economy of Japan, Overseas Business Reports,* Department of Commerce, December, 1966.

Table Q-5

U. S. EXPORTS TO AUSTRALIA

(Thousands of Dollars)

Mineral	1955	1956	1957	1959	1960	1961
Copper & copper alloys	6,657	1,418	815	N/A	N/A	N/A
Iron & Steel mill products	8,315	3,539	5,450	2,447	20,200	5,248

Sources: *Economic Developments in Australia, 1958,* World Trade Information Service, U. S. Department of Commerce.

Basic Data on the Economy of Australia, Overseas Business Reports, Department of Commerce, March, 1963.

Table Q-6

AUSTRALIA'S PRINCIPAL METAL AND MINERAL TRADE

(Thousands of Dollars)

Imports	1964-65	1965-66
Aluminum	2,891	5,167
Asbestos	5,008	6,348
Copper	42,076	4,116
Iron & steel	103,056	86,725
Petroleum	240,838	25,904
Sulphur	6,478	9,286
Tin	5,894	1,918
Exports		
Asbestos	1,346	1,449
Bauxite	2,496	3,380
Black Coal	51,216	62,976
Copper	18,890	79,877
Gold	18,406	24,417
Ilmenite	2,662	3,776
Iron & steel	62,173	73,075
Iron Ore	820	2,705
Lead	82,258	90,336
Rutile	17,508	17,562
Silver	2,226	764
Zinc	41,296	45,004

Source: *Australia in Facts and Figures*, Australian Department of the Interior, Canberra, No. 91.

APPENDIX R

CATALOG OF ALTERNATIVES

(Relevant to Chapter 17)

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APPENDIX R

CATALOG OF ALTERNATIVES

This appendix provides a list of alternatives to the existing laws pertaining to the use of the nonfuel-mineral resources on the public lands of the United States. These alternatives are in addition to the list contained in Appendix III of the *Legal Study of the Nonfuel Mineral Resources,* prepared by Twitty, Sievwright and Mills of Phoenix, Arizona.

For the most part, the alternatives listed herein are not grouped into any comprehensive system or systems but merely represent a collection of proposals that have come to the attention of the Contractor. Inclusion herein, even of an alternative developed by the Contractor, does not imply any preference for that alternative on the part of the Contractor.

Many of the alternatives listed have a wide range of possible variations. No attempt has been made to include all or even a major portion of these variations. Each alternative doubtlessly has advantages and disadvantages in addition to those listed. No attempt has been made in the appendix to do more than briefly list the more obvious advantages and disadvantages of each system. It must also be kept in mind that advantages and disadvantages must be considered with respect to something and from the point of view of someone. In each case, the advantages and disadvantages are listed with respect to the existing system while they are considered (hopefully) from the point of view of the best interest of the majority of the people of the United States.

1. **Alternative 133**

   a. The mineral laws of the United States shall apply only to public land to be used specifically for actual mining and exploration purposes.
   b. Issues and problems treated:
      (1) Use of lands obtained under the mining laws for purposes other than mining.
      (2) The holding of large areas of land at minimal cost under the mineral laws.
      (3) Problems of environmental control.
   c. Major features of the alternative:
      (1) The mining and mineral leasing laws would apply only to that public land specifically used or to be used in actual mining operations.
      (2) Land to be used for beneficiation and advanced processing plants, and other surface activities not specifically involved in the removal of a mineral commodity from the earth, would have to be acquired under the provisions of other legislation.
   d. Probable advantages:
      (1) Some abuses (i.e. use of the land for non-mining purposes) of the mining laws could be eliminated or diminished.
      (2) Waste disposal practices could be more effectively controlled.
   e. Probable disadvantages:
      (1) In many cases beneficiation and advanced processing operations are an integral part of mining operations.
      (2) What surface activities actually are involved in mining itself is still rather a vague concept.
      (3) Abuses of the arbitrary authority of government agencies could increase substantially.
   f. Source: The Contractor

2. Alternative 134

a. Application of the Mining Location Law to all minerals normally found in a solid state with the Mineral Leasing Law applicable only to minerals found normally in a fluid state.

b. Issues and problems treated:
  (1) Problems arising from the multiplicity of applicable legislation.
  (2) Unrealistic commodity distinctions.
  (3) Unrealistic geographic distinctions.
  (4) Uncertainties of mineral land tenure when "new" mineral commodities or "common" varieties are involved.

c. Major features of the alternative:
  (1) Minerals normally found in nature in a fluid state, i.e., petroleum, natural gas, helium, carbon dioxide, water, steam, and salt brines, would be made subject to the Minerals Leasing Act.
  (2) All other minerals, i.e., those normally found in nature in a solid state, would be made subject to the provisions of the Mining Law of 1872, as amended.
  (3) A variation could make those solid mineral commodities normally found in an unconsolidated state, i.e., sand and gravel, topsoil, and placer metals, subject to the Mineral Leasing Law.

d. Probable advantages:
  (1) Many uncertainties in mineral land tenure could be diminished.
  (2) Unrealistic and arbitrary commodity distinctions could be eliminated.
  (3) Arbitrary abuse of commodity definitions by administering agencies could be diminished.
  (4) Greater incentives for the more effective use of many so-called "leaseable" minerals could be achieved by placing them under the Mining Location Law.

e. Probable disadvantages:
  (1) Mineral leasing revenues could decline.
  (2) If adequate amendments were not made to other features of the Mining Law of 1872, severe land control abuses could develop.

f. Source: The Contractor, as stated, although a similar distinction is, in effect, made by the state of Oregon in its legislation concerning mineral resources on state lands.

3. Alternative 135

a. Patents or leases of mineral lands would be for specific depths below original surface. Surface rights would extend to a depth of 500 feet from original surface.

b. Problems and issues treated:
  (1) Problems arising from the severance of surface and mineral rights.
  (2) Conflicts between the users of land surface and the minerals resources located on or under them.

c. Major features:
  (1) All holders of surface rights would be deemed to have all land and mineral rights to a depth of 500 feet from the original surface at the time the surface rights were acquired.
  (2) All potential mineral resource users would be issued patents or leases for all minerals within specified depths from the original surface at the time of issuance. These depth ranges would be variable but would be in increments of 500 feet.
  (3) All public land rights would thus become volume rights, including not only

area but depth and all resources contained within that volume.

d. Probable advantages:
  (1) Many of the problems resulting from the severance of surface and mineral rights could be eliminated.
  (2) Many of the conflicts between surface and mineral resource users could be eliminated.
  (3) Some of the potential problems of reserved mineral rights could be minimized.

e. Probable disadvantages:
  (1) The arbitrary 500 foot depth dimension would probably have to be increased as surface mining technology changes.
  (2) Highly irregular land surfaces could cause problems.

f. Source: The Contractor, as stated, although depth distinctions are commonly used in dealing with coal on private lands.

4. **Alternative 136**

a. Composite system involving both public and private tenure during varying phases of mineral resource utilization and the use of a convertible franchise.

b. Issues and problems treated:
  (1) Problems arising from the multiplicity of and variation in applicable legislation, including:
    (a) variations according to geological variables.
    (b) variations according to geographic variables.
    (c) variations according to agency of jurisdiction.
  (2) Problems arising from the inconsistencies of the existing law with technical and economic reality, including:
    (a) inconsistencies in resource definition.
    (b) inconsistencies in mineral exploration.
    (c) inconsistencies in mineral development.
    (d) inconsistencies in mineral production.
    (e) inconsistencies in post-production practice.
  (3) Abuses of the mining laws.

c. Major features of the system:
  (1) Surface and mineral rights on the public lands would be retained by the federal government until such time as actual mineral production were initiated, at which time, ownership would be transferred to the private producer.
  (2) All public land areas would be open to mineral reconnaissance activities by private entities. Exploration activities, including target area examination and deposit evaluation, as well as mineral deposit development would be conducted by private entities under an exploration and development franchise which would involve a specific area for a specifice time. The holder of an exploration and development franchise would be allowed to convert a relevant part of the franchised area to ownership in fee simple upon the initiation of mineral production.
  (3) Original public domain and acquired lands would be considered alike and both included in the system. Surface rights, mineral rights and subsurface rights would be tied together. Where mineral rights have been reserved to the federal government and surface rights have been transferred to private (including state) ownership, the reserved mineral rights would be deeded to the existing owner of the surface rights.
  (4) All public land mineral activities would become the responsibility of an

agency of the Department of the Interior. Excluded would be those lands legally designated and actually used for specific federal purposes such as national defense installations, national parks and monuments, and public buildings. Included in the system would be the national forests, national wildlife refuges, national recreation areas, and all lands directly administered by the Bureau of Land Management.

(5) All mineral commodities would be included in the system. No commodity distinctions would be made.

(6) Payments for exploration and development franchises would be made as rental payments on the surface value of the land area involved. Payments for lands received in fee simple title would be on the basis of the surface value of the land.

(7) Exploration and development franchises would be awarded on a first-come, first-serve basis, but would be limited to a minimum time and renewable only once. Specific time limits would be set inversely proportional to the amount of area involved. Time limits would be minimized in accordance with technical realities in order to encourage performance by the franchise holder.

(8) The surface area involved in any exploration and development franchise would be in multiples of quarter, quarter sections and related to the federal land survey. There would be a maximum franchise area established. Lands transferred to private ownership upon initiation of production would also be related to the federal land survey and would be subject to both maximum and minimum limits.

(9) The obligations of the federal government would include:

    (a) the obligation to provide information about the public lands, including land survey and basic geologic data.
    (b) the obligation to award exploration and development franchises to private entities upon compliance with specified procedures.
    (c) the obligation to transfer title in fee simple to specific lands for mineral use upon compliance with specified procedures and under specified conditions.
    (d) the obligation to protect authorized mineral users from other users of the public lands.

(10) The rights of the federal government would include:

    (a) the right to obtain certain basic information about the mineral resources and the public lands.
    (b) the right to prohibit certain activities on the public lands.
    (c) the right to require the control of effects upon the environment of mineral exploration and development.
    (d) the right to require the performance of specific amounts of mineral exploration and development work on the public lands.
    (e) the right of access to the public lands for itself and other users.

(11) The obligations of the private mineral resource seeker and/or developer would include:

    (a) the obligation to perform specified amounts of work under a franchise and specified amounts of production in order to obtain title in fee simple.
    (b) the obligation to provide certain basic data to the federal government.
    (c) the obligation to control the adverse effects of his activity upon the environment.
    (d) the obligation to permit access to public lands by other users where conditions of health, safety, and the security of personal property so permit.

        - (e) the obligation to follow specific procedures in obtaining the right to operate on or receive title to public lands.
    - (12) The rights of the mineral resource seeker and/or developer would include:
        - (a) the right of access to the public lands for reconnaissance purposes.
        - (b) the right to obtain information about the public lands.
        - (c) the right to remove one or more mineral commodities from the public lands.
        - (d) the right to use the surface of the land for activities related to mineral exploration and development.
        - (e) the right of preferential tenure in the event of the discovery of a useable mineral deposit.
        - (f) the right to use other than mineral resources on the public lands in the process of mineral exploration and development.
        - (g) the right to exclude other users of the public lands from franchised areas for reasons of health, safety, and the security of personal property.
- d. Probable advantages of the system:
    - (1) Problems arising from the multiplicity of applicable legislation would be eliminated.
    - (2) Problems arising from the inconsistencies of the law with technical and economic reality could be eliminated.
    - (3) Uncertainties of mineral tenure would be eliminated.
    - (4) Abuses of the existing law could be eliminated.
    - (5) The incentives toward mineral resource development by private industry would be increased.
    - (6) Competitive conditions in the mineral industry could be enhanced.
    - (7) Interests of non-mineral users of the public lands could be protected.
- e. Probable disadvantages of the system:
    - (1) There would be a short-term decline in federal revenues from mineral leasing.
    - (2) There could develop some inter-agency problems in administration.
- f. Source: The Contractor.

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NONFUEL MINERAL RESOURCES
AND THE
PUBLIC LANDS

SUMMARY REPORT

Prepared for
The United States Public Land Law Review Commission

by

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1. THE NONFUEL MINERAL RESOURCES OF THE PUBLIC LANDS

A. What The Nation's Nonfuel Mineral Resources Are

Although a number of estimates have been made since 1947 of the total nonfuel mineral reserves of the United States, for the most part such estimates have not been substantiated by subsequent production figures. These estimates have involved various concepts of what constitutes a mineral reserve and differing assumptions regarding unknown but existing geologic circumstances and future economic and technological conditions. As a result, the estimated reserves of the many nonfuel mineral commodities found in the United States have varied widely. At the present time the actual reserves of all economically useful minerals in the United States are unknown, and probably cannot be measured with any degree of accuracy within reasonable limits of cost and time. For most industrial minerals, even the concept of a national mineral reserve is fallacious, for most such mineral commodities are not produced for or used in a national market.

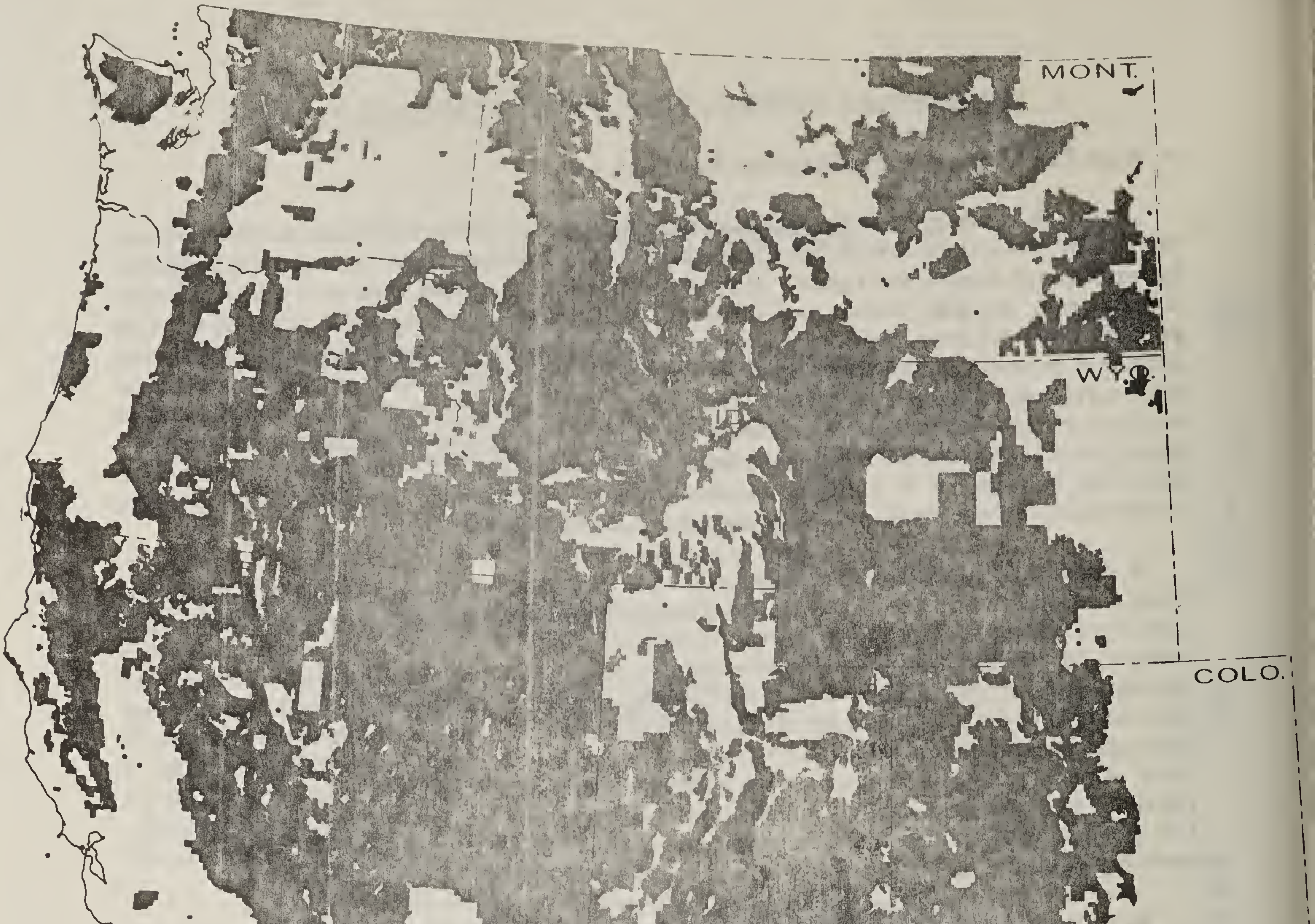
A number of fundamental changes occurred in the major characteristics of the nonfuel mineral resources utilized in the United States after 1870, and some of these changes have continued during the post-World War II period. Since the 1860's, the average valuable content (in per-unit terms) of known useable mineral deposits in the United States has declined substantially. Since 1947, the average grade of nearly all mineral deposits has likewise followed a downward trend. Economically useable deposits of limestone and several other industrial minerals used in construction, however, are exceptions to this. For many of these minerals, quality standards have increased, and such standards may be expected to continue to increase as long as competition remains in the markets for industrial minerals. For most mineral commodities, however, the average grade of useable mineral deposits will probably continue to decline over the next two decades.

Since both 1870 and 1947, the average size of mineral deposits utilized in the United States has increased markedly, although there have been some significant exceptions, mostly in industrial minerals. In some instances, too, the known size of many individual mineral deposits initially developed prior to 1947 has been expanded since that time because of changing technical and economic conditions and increased geologic knowledge.

In general, mineral deposits brought into production since 1947 have been initially more concealed than those developed prior to that time. In many instances, however, the mineral deposits were previously known to exist but were not considered economically attractive until more recent years. The surface indications of mineral deposit existence (or potential existence) have continued to be important, although they are now less direct than in the last century.

The major geological features of mineral deposits utilized in the United States have changed substantially since the 1860's. Useable placer deposits are virtually non-existent today, except as sources of sand and gravel for construction purposes. Simple lode or vein deposits are also far less important than in the last century. Since the early 1900's, and particularly since World War II, large, disseminated mineral deposits have assumed far greater importance.

By 1985, some changes may be expected in the geological characteristics of mineral deposits providing new production, but most structural features will probably remain as at present. The importance of large, disseminated mineral deposits will probably spread to commodities such as gold, silver, and mercury, which are still mined mostly from the geologic environments in which they were found in the 1860's. Technological changes in extractive metallurgy will probably have a strong influence on the characteristics of newly


MONT.
WYO.
COLO.
ARIZ.
N. MEX.
LANDS ADMINISTERED BY THE:
Nat'l Park Service and Bur. of Sports Fisheries and Wildlife
Nat'l Forest Service
Bur. of Land Management
THE PUBLIC LANDS OF THE WESTERN UNITED STATES

Source: U.S. Bur. of Land Management
Drawn by Chavez

Fig. 1 - The public lands of the United States cover wide areas of the 11 Western States. Although most of the public lands are administered by the Bureau of Land Management, substantial areas are also under the jurisdiction of other agencies of the Department of the Interior as well as the United States Forest Service. Nearly all of the West's principal mountain ranges are under the control of the Forest Service.

developed deposits of metallic minerals. Technological changes in beneficiation, chemical processing, and minerals using activities will also have profound effects on the characteristics of newly developed deposits of industrial minerals. The relative importance of co- and by-product mineral commodities has increased measurably for some metals since 1947 while declining for others and may be expected to continue to change erratically over the next 15 to 20 years.

The average size of mineral deposits brought into production over the next 15 to 20 years will probably increase as valuable mineral content declines. This will not be a consistent pattern for all commodities, however, and it is expected that smaller deposits, particularly of industrial minerals, will still be important. As minerals exploration continues, it can be expected that more of the newly found deposits brought into production will be those which are either concealed at present or, if known, are now considered unattractive economically.

The major metallic minerals presently being produced in the United States include ores of the precious metals (gold and silver), iron and various ferrous-allowing metals (such as nickel, molybdenum, and tungsten), the non-ferrous base metals (copper, lead, and zinc), and several miscellaneous metals (such as mercury and beryllium) that have become of critical importance in the electronics and aerospace industries, and uranium. In addition the United States also possesses workable deposits of many industrial minerals including limestone, gypsum, phosphates, potash, sodium minerals, asbestos, and sand and gravel. Numerous other mineral commodities are also produced in lesser, but significant amounts.

B. Where The Nation's Nonfuel Minerals Are

There have been definite shifts in the location of the nation's known nonfuel mineral resources since the 1860's. At that time, as shown in the accompanying map, nearly all of the known mineral resources of the United States were located east of the Mississippi River. The major exceptions were gold and mercury. Since then, however, the Western United States has increased greatly in importance as a known source of both metallic and nonmetallic minerals, as shown in the accompanying map reflecting the present known mineral resource situation. Since 1947, while there have been few changes in the location of known metallic mineral resources, there has been a substantial increase in the importance of the Western States as a source of industrial minerals.

The reasons for the changes in the location of known nonfuel mineral deposits in the United States have been both geologic and economic. The mountainous areas of both the East and West are geologically suitable for metallic mineral deposition, while such deposition in the central part of the continent has been relatively sparse. Since the Treaty of Guadalupe-Hidalgo, however, vast areas of the geologically attractive West have been open for minerals exploration and acquisition while most districts in the geologically attractive areas of the East were not as readily explored or acquired for mineral purposes. This was partly because of technical exploration problems and partly because of difficulties resulting from land ownership patterns. The development of industrial minerals resources, which are usually high-bulk, low-value commodities that can only be shipped for relatively short distances, has followed the general population shift across the nation. The development of industrial minerals deposits has been almost completely dependent upon the prior development of local industrial or consumer markets.

That portion of the contiguous 48 United States lying west of the 105th Meridian does have some geological characteristics that are significantly different from the area to the east. In general, the topography is more abrupt, the surface rocks are younger and have undergone erosion for a shorter period of time, and volcanic activity and movements of the

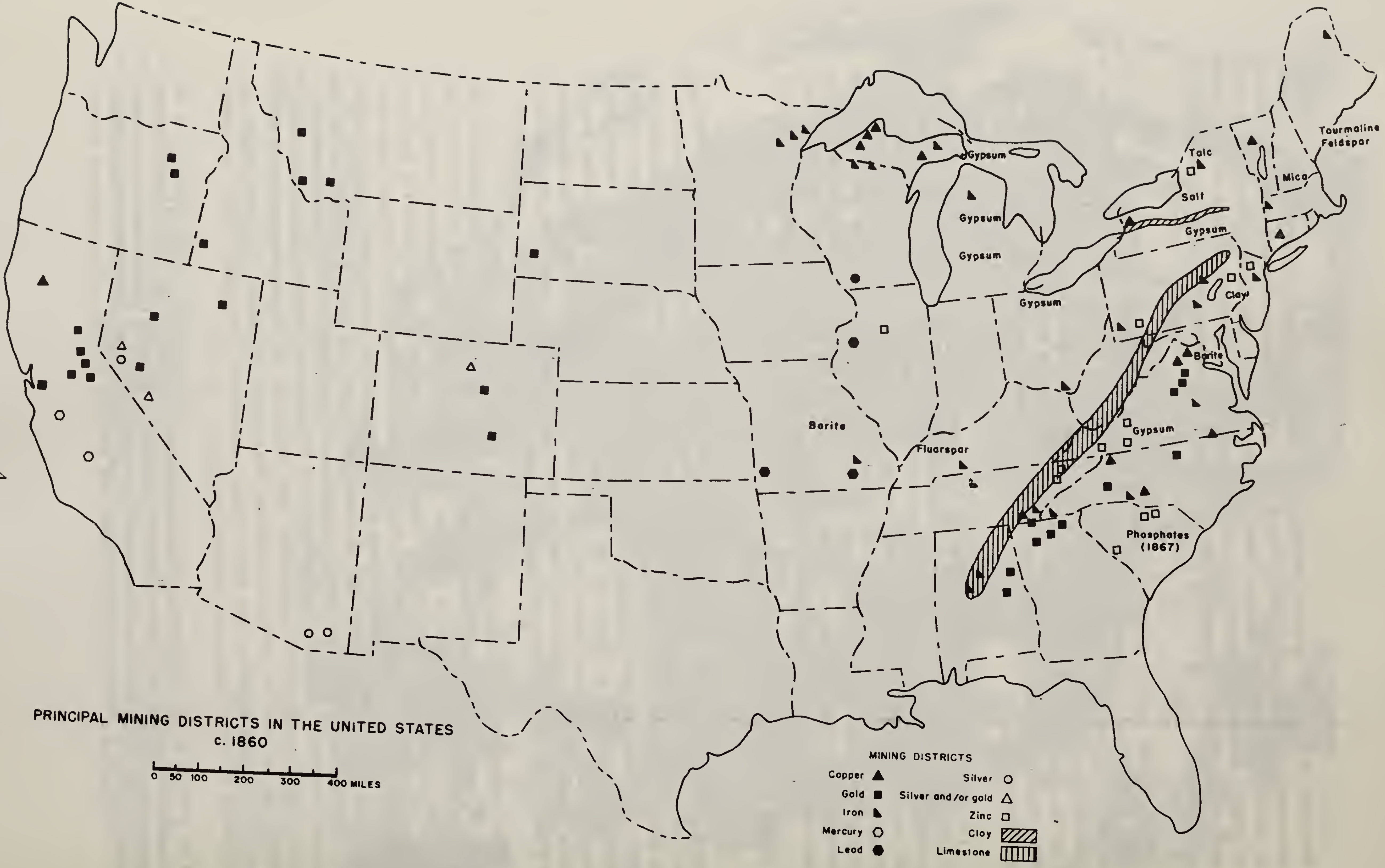
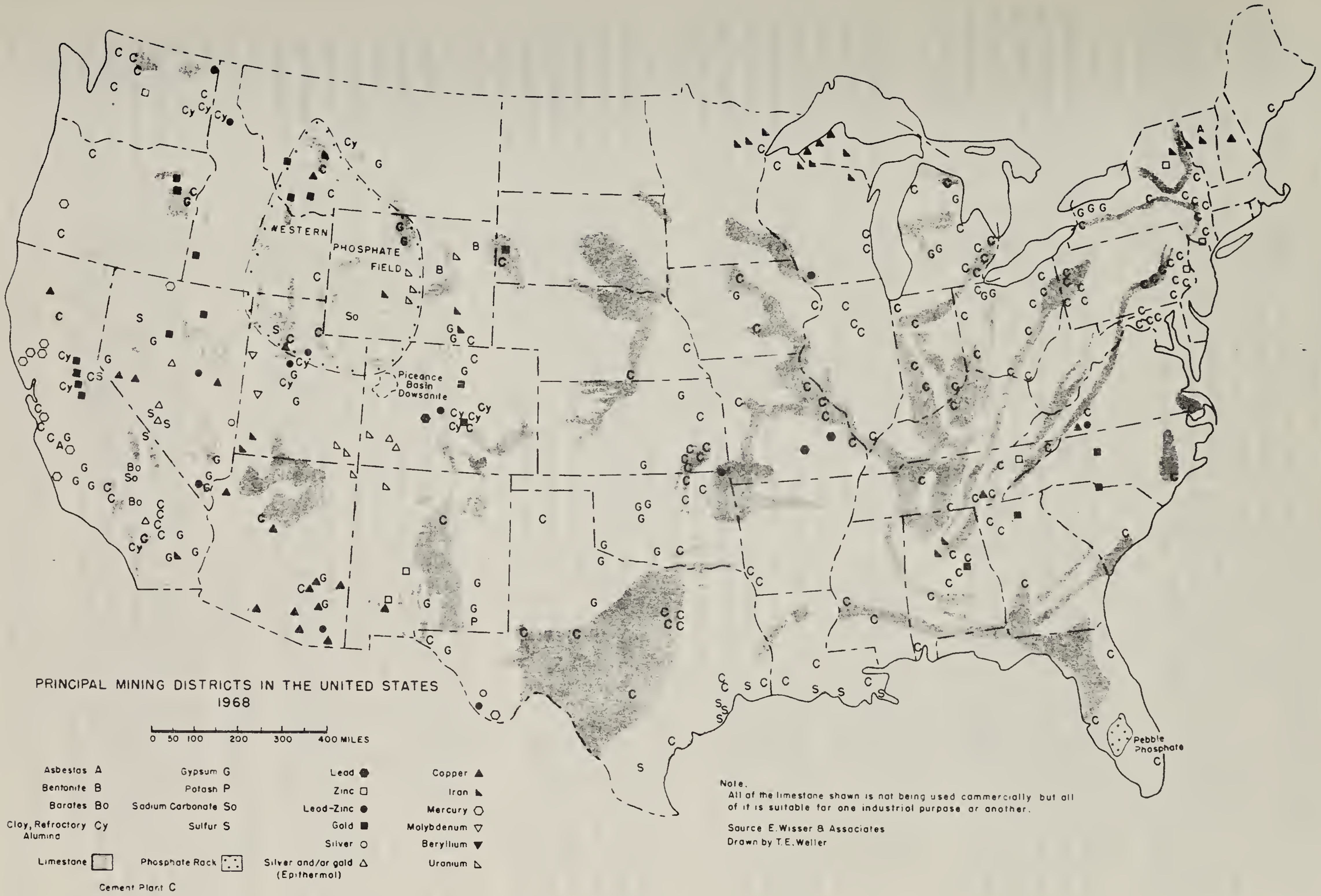


Fig. 2 - Prior to the 1860's virtually all of the known mineral resources of the United States were situated east of the Great Plains. Only some gold, silver, and mercury deposits had been developed to any extent in the West.


PRINCIPAL MINING DISTRICTS IN THE UNITED STATES
1968

Note.
All of the limestone shown is not being used commercially but all of it is suitable for one industrial purpose or another.

Source E.Wisser & Associates
Drawn by T.E.Weller

Fig. 3 - By mid-20th Century, most of the nation's known resources of metallic minerals (except iron) were situated in the West. The region also contains substantial amounts of industrial minerals, some of which have been found in significant amounts only in the West.

earth's crust have been more recent within the Western Region. Furthermore, large areas of the West are semi-arid and only sparsely covered by vegetation.

In the area between the Rockies and the Appalachians, however, the land is relatively flat lying, more thickly covered with vegetation, and noticeably devoid of any major igneous activity in recent time. In the Appalachian Mountain Region, tectonic activity is again apparent but the surface rocks are generally much older than in the Mountain West and topography is not nearly so abrupt. Furthermore, the climate of the Eastern United States is generally much more humid, and the area is covered with relatively heavy vegetation.

Both the Mountain West and the Appalachian Mountain Region are geologically favorable for metallic mineral deposition, however, as are some minor mountain areas (e.g., Northern Minnesota and Southeast Missouri) in the central part of the continent. Even in the Plains States, many industrial minerals are prevalent as are selected metallics. There is little doubt that many areas of the United States contain minerals that are not now considered commercially attractive but which could become so. This is particularly true in the 11 Western States area.

Representative of many industrial minerals the rock type, *limestone,* actually represents a variety of mineral commodities which differ according to their precise chemical composition (including impurities), their physical properties, and their location. Thus, some limestone are suitable for building stone, some as metallurgical flux, some in the making of agricultural lime, some for cement, and others for assorted chemical and construction materials uses. The exact proportions of the total available limestone suitable for each of these uses is unknown. Furthermore, as economic and technical conditions change, the suitability of the West's limestone resources for specific uses will also change. The same is true of many other of the industrial minerals resources of the West.

A significant portion of those areas of the West in which the surface lands have passed to private ownership but in which the mineral rights have been reserved to the federal government are likely to become targets for nonfuel minerals exploration and development before 1975. In fact many such areas already are attractive targets for both metallic and nonmetallic minerals exploration. In many instances, too, such areas, while geologically attractive, have not been explored because of anticipated or actual conflicts with surface land owners.

There have been changes in the number of claims patented and nonfuel mineral leases granted on the public lands since 1947. Changes appear to be related to the increased demand for mineral commodities but also reflect changes in the administration of public land policy by both the Department of the Interior and the Forest Service. There have also been changes in the total value of all minerals produced from public lands but the records are inadequate (they do not include production from unpatented mining claims) to quantitatively substantiate any firm conclusions regarding the effects of public land policy on nonfuel mineral resource development and production on the public lands.

C. How Nonfuel Minerals are Utilized

There have been many significant changes in the conduct of nonfuel minerals exploration in the United States since the 1860's. Since 1947 these changes have been influenced by a number of factors and have followed several discernible trends that can be projected into the 1980's. These changes have involved the methods and techniques used in the search for nonfuel minerals as well as the commodities sought and the entities and organizations engaged in minerals exploration.

In the 1860's the principal items sought by those searching for nonfuel minerals were gold, silver, and frequently mercury and other minerals associated with the production of gold and silver. Today, however, base metals, uranium, and industrial minerals are the most sought after by those seeking nonfuel minerals in the United States.

Exploration for nonfuel minerals in the 1860's was conducted mostly by individual prospectors or small groups of prospectors working for their own account. Today, the lone prospector is still an active seeker of minerals in the United States, but his work has been supplemented by the activity of major minerals producing firms with large staffs of geologists and engineers. In most instances the activities of these two groups in seeking nonfuel minerals on the public lands of the United States are complementary, and neither one could perform well without the work of the other. Since 1947 there has been a decided increase in the number of minerals produced with full-time, professional exploration staffs. In recent years, however, some of the exploration work previously performed in-house by major minerals producers has been subcontracted, resulting in a situation in which the smaller minerals exploration firm or the individual professional geologist, operating as a consultant, has returned and increased in importance. It is expected that between now and 1985, those seeking minerals on the public lands of the United States will include members of all three groups, including individual prospectors working for their own account, major minerals producers with sizable exploration staffs, and small mineral exploration consultants working for either an established minerals producer or a land owner.

The specific methods and techniques used in nonfuel minerals exploration in the United States have changed substantially since 1860. At that time, visual geological and mineralogical anomalies served as the primary indications of the existence of a valuable mineral deposit. Now geochemical and geophysical anomalies have been added to these and have become of considerable importance in the search for nonfuel minerals. Diamond core drilling, developed in the very late 1800's, has become the primary tool used in the detailed examination of potentially valuable mineral deposits, replacing much of the need (in exploration) for shaft sinking and tunnel driving. The eye of the individual prospector has been supplemented (but not replaced) by aerial photography, geochemical surveys, geophysical surveys, and regional geologic study. Geologic inference from both surface and subsurface indications has become a vital element in virtually every minerals exploration project. Such inference is then usually tested by actual physical examination through the use of either drillholes or actual underground development. It is expected that by 1985 geophysical and geochemical means will become even more important in the search for nonfuel minerals in the United States. Nevertheless, they will not replace, but merely supplement the information obtained by surface geology work and actual examination of subsurfaces conditions by drilling or underground development.

The search for nonfuel minerals can be divided into three separate stages. The first is *regional reconnaissance*, which involves large areas and is normally done with little or no actual disturbance of the land. Much regional reconnaissance involves simply geologic mapping of surface (and inferred subsurface) conditions by aerial photography or by airborne geophysical procedures. The second stage of mineral exploration is *target area examination*. This involves the detailed surface examination of a particular target area determined to be both geologically attractive and acquirable from regional reconnaissance data. Detailed target area examination may also involve the drilling of some widely scattered diamond drill holes, primarily to test the inferences made from data acquired from the surface. The third stage of minerals exploration is *deposit evaluation*. This normally involves the intensive drilling of a potentially valuable mineral deposit to determine its actual physical, chemical, and mineralogical characteristics.

The methods and techniques used in minerals exploration vary somewhat depending upon the particular commodity being sought, although certain methods (e.g., core drilling) are commonly used with many commodities. Geophysical and geochemical techniques are now widely used in the search for metallic minerals. The specific techniques vary, however, depending in many cases upon the particular metal being sought. For example, if iron ore is the objective of the mineral seeker, magnetic geophysical methods are quite useful. Although also used in the search for other heavy metals the usefullness of magnetic methods in such exploration is limited to obtaining basic geologic data from which inferences may be made regarding the existence of metalliferous deposits. Other geophysical methods also vary in application, finding their widest nonfuel use in the search for metallic mineral deposits. Some techniques, however, are used specifically to find deposits of industrial minerals. These methods provide only indicators, however, and cannot be used to prove the existence of valuable mineral deposits.

The three different phases of the minerals exploration process have different objectives. The objective of *regional reconnaissance* is to find a specific area that is attractive for detailed examination. Subsequently, the objective of the *target area examination* phase is the finding of a *potentially* valuable deposit of a metallic ore mineral or a particular industrial mineral. The objective of the third stage, *deposit evaluation,* is to determine whether or not the deposit that has been found is commercially useable and to delineate its extent, define its physical, chemical, and mineralogical characteristics, and obtain other data sufficient to determine the feasibility of mining operations. In the three different phases, different methods and techniques of minerals exploration are normally used. Airborne work, library research, and broad-brush surface exploration normally are used in regional reconnaissance. In the last stage, that of deposit evaluation, drilling by diamond drills or churn drills, as well as some underground development, are normally used. The second stage, target area examination, frequently uses a combination of the methods used in phases one and three.

The various phases of the minerals exploration process involve different time spans. These will vary from a few months to many years for regional reconnaissance, from virtually nothing to 20 years for target area examination, and from three months to 10 years for deposit evaluation. (See Chapter 8, Volume II of the complete report.) In many instances, if not in all, deposit evaluation is a continuing process carried on even after actual mine development and production have begun. For some properties (e.g., Bingham Canyon), this has lasted more than 100 years.

The different methods and techniques used in minerals exploration also require different lengths of time. Underground excavation to obtain bulk samples and to delineate an orebody usually requires the greatest amount of time, although drilling programs may also extend over a number of years. Airborne and other geochemical and geophysical surveys can also require considerable lengths of time depending upon the intensity of the survey and the total area involved. These times also vary according to the effort which the particular minerals seeker is willing to devote to any one project.

The costs incurred in the several phases of the minerals exploration process normally vary considerably, as do the costs of the various techniques and methods used in minerals exploration. Under normal conditions, the costs involved in an exploration program are related directly to the potential return from the finding of a valuable mineral deposit. Expenditures are related to the potentiality for success. Under normal conditions, as an exploration program proceeds, the expenditures are increased so long as there is a reasonable possibility of finding a valuable mineral deposit of a size adequate to return the costs incurred to the mineral seeker. As a result, exploration costs per unit of area incurred during the regional reconnaissance stage are normally much less than the costs incurred during the deposit evaluation stage of minerals exploration. Total expenditures, of course, also vary according to the size of the project and according to the exploration methods used. The costs of various exploration methods and techniques differ, and exploration costs also vary

Table 1

REPRESENTATIVE TIME INTERVALS INVOLVED IN MINERALS EXPLORATION IN THE UNITED STATES, 1947-1968

Successful Project (ranked by length of time)	Commodity Sought	Time for Target Area Examination[a] (months)	Time for Deposit Evaluation[b] (months)	Total Exploration Time[c] (months)
1	Gold-Silver	240	120	360
2	Lead	60	84	144
3	Uranium	12	120	132
4	Copper	48	60	128
5	Molybdenum	36	60	96
6	Copper-Silver	72	12	84
7	Lead	36	36	72
8	Salt	12	60	72
9	Phosphate	36	24	60
10	Phosphate	36	24	60
11	Lead	24	30	54
12	Limestone	28	24	52
13	Iron	24	24	48
14	Gypsum	36	12	48
15	Uranium	12	36	48
16	Iron	27	21	48
17	Copper	–	36	36+
18	Copper	–	36	36+
19	Copper	–	36	36+
20	Clay	12	24	36
21	Lead	12	24	36
22	Gypsum	24	12	36
23	Gypsum	24	12	36
24	Potash	24	12	36
25	Metal	18	12	36
26	Molybdenum	12	24	36
27	Uranium	12	18	30
28	Copper-Zinc	6	24	30
29	Gypsum	24	6	30
30	Metal	24	6	30
31	Salt	6	24	30
32	Phosphate	12	12	24
33	Beryllium	6	12	18
34	Uranium	12	6	18
35	Barite	12	6	18
36	Phosphate	6	12	18
37	Iron	5	12	17
38	Copper	12	3	15
39	Uranium	8	6	14
40	Metal	6	6	12
41	Metal	6	6	12

(Continued on following page)

Table 1 (Continued)

42	Industrial Minerals	6	6	12
43	Sand	6	6	12
44	Copper	0	11	11
45	Uranium	2	8	10
46	Uranium	–	4	4+
47	Uranium	–	3	3+

[a] Time from selection of target area to determination of target deposit.

[b] Time from selection of target deposit to confirmation of its status as an orebody.

[c] Does not include that deposit evaluation time aggregated with mine development time.

Source of Data: Survey conducted by the Division of Economic and Business Research, The University of Arizona.

from one region of the country to another. In most minerals exploration efforts, the attempt is made to obtain the most information for the least cost. For this reason, diamond drilling is used in preference to underground excavation wherever possible in both target area examination and deposit evaluation.

Different land areas are involved in each of the several phases of minerals exploration. In the regional reconnaissance phase thousands of square miles may be involved. In the deposit evaluation stage the area involved in exploration, particularly in deposits such as high unit value uranium orebodies, may run down to only a few acres. In most cases, however, the deposit evaluation stage will require from 50 to 2,000 acres. The target area examination stage normally involves an area that is dependent upon the type of deposit being sought and upon the geologic conditions recognizable from the surface.

The different methods and techniques used in minerals exploration are likewise normally associated with different land areas. Airborne reconnaissance methods are used to cover extremely large areas, while underground excavation and core drilling are used to examine the smallest areas. Geophysical and geochemical surveys may be run either on tight or spread patterns and are quite variable in the land areas for which they may be appropriate.

The probabilities of success in nonfuel minerals exploration are quite variable and differ essentially according to the mineral commodities sought. It is extremely difficult to estimate precisely the probabilities of success in minerals exploration, since success may be defined in different ways and since failures are usually not as well recorded as are successes. It may be generalized, however, that the probabilities of success in the search for metallic minerals are less than the probabilities of success in exploration for industrial minerals. This is a generalization, however, and exceptions are numerous. In many instances the probabilities of success in finding a deposit of specific industrial minerals meeting exacting specifications can be even less than in an attempt to find a deposit of metallic minerals.

Different exploration entities have had varying degrees of exploration success. Variation has been considerable even among major minerals producers, however, and seems dependent entirely upon the ability of the individual minerals seeker to infer the potential for valuable mineral deposition from observable geologic, geophysical, and/or geochemical conditions. The small miners and prospectors have generally had equivalent or greater success in the last two decades than have the highly organized exploration departments of most major minerals producers. In fact, many of the successes of the major minerals producers have been the direct result of the preparatory work of small miners and prospectors. Exact success records have been impossible to ascertain, however, because of an extreme scarcity of available data.

It is indeterminate whether there has or has not been any measurable trend in the allocation of exploration effort between foreign and domestic areas by the United States minerals producers since 1947. In many instances the producers themselves do not have information adequate to determine the relative effort made between foreign and domestic areas. The same is true regarding the determination of any measurable trend in the allocation of exploration effort between public and private lands in the United States. As a generalization, however, since the middle 1800's there has been a decided emphasis on nonfuel minerals exploration activity on the public lands of the Western United States as compared to such activity on private lands east of the Mississippi. It is also indeterminate at this time as to whether or not there has been any measurable trend since 1947 in the allocation of exploration effort to established mining districts in preference to currently nonproducing areas. Subjective impressions, however, indicates that such has been the case, and that effort in established mining districts and known mineralized areas has been much more intense than in non-producing areas. This situation has been changing within the last

Table 2

REPRESENTATIVE MINERAL EXPLORATION COSTS IN THE UNITED STATES, 1947-1968

(Developed Properties)

Successful Project (ranked by total cost)	Commodity Sought	Cost of Target Area Examination[a]	Cost of Deposit Evaluation[b]	Total Exploration Cost[c]
1	Uranium	$650,000	$3,918,000	$4,568,000
2	Lead	—	1,134,000	1,134,000+
3	Lead	350,000	650,000	1,000,000
4	Phosphate	300,000	600,000	900,000
5	Copper	100,000	600,000	700,000
6	Copper	—	508,000	508,000+
7	Lead	150,000	350,000	500,000
8	Copper	—	421,000	421,000+
9	Iron	40,000	342,400	382,400
10	"Metal"	—	382,000	382,000+
11	"Metal"	—	310,000	310,000+
12	Phosphate	85,000	200,000	285,000
13	"Industrial mineral"	175,000	50,000	225,000
14	Phosphate	75,000	150,000	225,000
15	Uranium	10,000	200,000	210,000
16	Phosphate	50,000	150,000	200,000
17	Salt	120,000	50,000	170,000
18	Potash	50,000	100,000	150,000
19	Iron	31,700	90,200	121,900
20	Iron	30,000	62,500	92,500
21	Uranium	30,000	50,000	80,000
22	Sand	10,000	60,000	70,000
23	Clay	10,000	50,000	60,000
24	Limestone	10,000	41,200	51,200
25	Uranium	5,000	26,000	31,000
26	Beryllium	5,000	25,000	30,000
27	Uranium	0	28,000	28,000
28	Uranium	0	16,000	16,000
29	Barite	10,000	5,000	15,000
30	Lead	10,000	—	10,000+

[a] Cost from selection of target area to determination of target deposit.

[b] Cost from selection of target deposit to confirmation of its status as an orebody.

[c] Does not include those deposit evaluation costs aggregated with mine development costs.

Source of Data: Survey conducted by the Division of Economic and Business Research, The University of Arizona.

Table 3

REPRESENTATIVE MINERAL EXPLORATION COSTS IN THE UNITED STATES, 1947-1968

(Rejected Properties)

Unsuccessful Project (ranked by total cost)	Cost of Target Examination[a]	Cost of Deposit Evaluation[b]	Total Exploration Cost[c]
1	$ 50,000	$850,000	$900,000
2	446,900	439,900	886,800
3	25,000	570,000	595,000
4	50,000	500,000	550,000
5	100,000	400,000	500,000
6	—	428,000	428,000+
7	—	311,000	311,000+
8	200,000	100,000	300,000
9	50,000	250,000	300,000
10	100,000	191,300	291,300
11	—	279,000	279,000+
12	50,000	200,000	250,000
13	—	243,000	243,000+
14	68,000	134,500	202,500
15	100,000	100,000	200,000
16	50,000	150,000	200,000
17	4,500	182,000	186,500
18	5,000	155,000	160,000
19	4,500	154,000	158,500
20	25,000	120,000	145,000
21	1,500	139,000	140,000
22	9,000	128,000	137,000
23	5,000	123,000	128,000
24	94,000	6,000	100,000
25	17,000	75,000	92,000
26	10,000	60,000	70,000
27	6,000	60,000	66,000
28	16,000	45,000	61,000
29	5,000	48,400	53,400
30	2,500	47,100	49,600
31	17,800	24,700	42,500
32	26,000	14,000	40,000
33	20,000	20,000	40,000
34	25,000	10,000	35,000
35	—	30,000	30,000+
36	10,000	10,000	20,000
37	14,000	6,000	20,000
38	3,000	16,600	19,600
39	10,000	5,000	15,000
40	5,000	5,000	10,000
41	3,200	2,600	5,800
42	2,600	1,200	3,800

[a] Cost from selection of target area to determination of target deposit.

[b] Cost from selection of target deposit to rejection as a suitable prospect.

[c] Does not include regional reconnaissance costs.

Source of Data: Survey conducted by the Division of Economic and Business Research, The University of Arizona.

Table 4

SPATIAL REQUIREMENTS IN MINERALS EXPLORATION IN THE UNITED STATES, 1947-1968

Successful Project (ranked by extent of deposit)	Commodity Sought	Total Area Involved in Reconnaissance (acres)	Total Area Used for Detailed Exploration (acres)	Extent of the Developed Mineral Deposit (acres)
1	Salt	—	128,000	50,000
2	Clay	500,000	50,000	24,000
3	Potash	2,048,000	1,280	16,000
4	Phosphate	64,000	32,000	15,000
5	"Industrial minerals"	250,000	32,000	10,000
6	Phosphate	16,000	1,280	8,000
7	Phosphate	3,840	0	8,000
8	Gypsum	640,000	64,000	2,560
9	Iron	102,000	1,580	1,580
10	Gypsum	256,000	1,280	1,280
11	Gypsum	64,000	640	1,200
12	Phosphate	3,000,000	20,000	1,000
13	Lead	50,000	5,000	800
14	Beryllium	3,000	1,200	800
15	Iron	121,000	5,100	600
16	Copper	1,600	800	600
17	Salt	40,000,000	14,000	500
18	Lead	960,000	25,000	500
19	Lead	20,000	1,000	500
20	Copper	4,000	500	500
21	Lead	10,000	4,000	400
22	Gypsum	3,200	100	400
23	Sand	90,000	1,000	300
24	Copper	500	200	150
25	Copper	5,000	500	100
26	Silver-copper	NA	800	100
27	Barite	1,000,000	2,000	80
28	Uranium	5,120	320	80
29	Gold-silver	NA	1,550	80
30	Uranium	150	100	80
31	Copper	500	75	60
32	Limestone	2,500	46	46
33	Uranium	6,000	3,200	20
34	Uranium	5,000	40	5
35	Iron	1,900	90	4
36	Uranium	60	45	4
37	Uranium	3	3	4
38	Uranium	10,000	6	2
39	Uranium	5,000	40	1

Source: Survey conducted by the Division of Economic and Business Research, The University of Arizona.

few years, however, and with the refinement of new techniques of minerals exploration, may be expected to continue to change before 1985.

Significant changes have also occurred since 1860 in the technical and economic characteristics of mineral deposit development in the United States. There have likewise been changes since 1947, and these have followed discernible patterns which may be projected into the 1980's. A number of factors have influenced these changes. Innovations in the methods and techniques used in mineral deposit development have been influenced by the types of mineral commodities sought, the types of deposits in which these mineral commodities have occurred, and methods and equipment available for excavation.

Since 1860, perhaps the greatest change in mineral deposit development has been the growth in the importance of surface mining, with the resultant limitation on the need for underground development. Despite this, since the 1860's there has been a steady increase in the amount of development work required in the utilization of a valuable mineral deposit, whether it be mined by surface or underground methods. This has been a persistent trend in virtually all mineral commodities. It is continuing today and may be expected to continue until 1985.

The organizations and entities engaged in mineral deposit development have also changed since the 1860's. Mineral deposit development prior to 1872, and for a number of years thereafter, was performed principally by individual miners or by small companies formed explicitly to develop and utilize a single mineral deposit. With the increased importance of larger mineral deposits and the general growth in the nation's business structure, however, mineral deposit development has become largely the function of the multiple-property corporation. This trend has persisted since the early 1900's and may be expected to continue into the 1980's. Even for mineral deposits that are relatively small, it can be expected that relatively small minerals producers will be involved in the development of a number of properties rather than limiting themselves to the development of a single deposit. In recent years, a number of joint ventures have been formed for the development of particularly large mineral deposits. As the importance of large disseminated deposits increases, this joint venture arrangement (even among the largest minerals producers) may be expected to become more common.

The methods and techniques used in the development of mineral deposits vary not so much according to the mineral involved but according to the geologic structure in which that mineral occurs. The methods, the areas involved, and the time spans required for the development of deep, hidden mineral deposits are significantly different from the development methods, areas, and times associated with the development of relatively flat-lying, close-to-surface mineral deposits. The large disseminated orebodies common to the copper and molybdenum industries (and in the future perhaps even to the gold and silver producing industries) require development methods and techniques significantly different from those necessary in the development of relatively small, high-grade mercury orebodies. Perhaps the greatest difference, however, in mineral deposit development is found in deposits of minerals such as sulfur or potash that are developed for solution or a similar method of mining. In such cases, development methods and equipment are more like those used in the development of petroleum and natural gas deposits than in the development of deposits of other nonfuel minerals.

The time required to develop a mineral deposit depends not only upon the methods and techniques used but upon the size of the mineral deposit and the type of orebody being developed as well. Typical development periods for nonfuel mineral deposits brought into production since 1947 have ranged from eight months to 12 years, with the size of the deposit being the most critical factor in determining the time required to develop it.

Table 5
REPRESENTATIVE TIME INTERVALS INVOLVED IN MINE DEVELOPMENT IN THE UNITED STATES
1947 – 1968

Project (Ranked by Length of time)	Commodity	Development Time[a] (in months)
1	Barite	144
2	Iron	120
3	Copper	120
4	Potash	96
5	Evaporite	60[b]
6	Lead	60
7	Iron	50
8	Lead	48
9	Limestone	44
10	Lead	42
11	Copper	36
12	Clay	36
13	Molybdenum	24
14	Lead	24
15	Phosphate	24
16	Sand	24
17	Copper-Zinc	18
18	Uranium	18
19	Industrial Minerals	18
20	Gypsum	18
21	Uranium	16
22	Uranium	16
23	Gypsum	12
24	Uranium	12
25	Uranium	12
26	Uranium	12
27	Uranium	10
28	Uranium	8

[a] Time from recognition as an orebody to first significant production.
[b] Largely pilot plant testing.

Source: Survey conducted by the Division of Economic and Business Research, The University of Arizona.

The investment required to develop a mineral deposit has varied with the methods and techniques used as well as with the size of the deposit and the type of mineral involved. In virtually all instances, the investment made in developing a mineral deposit is related directly to the return expected from the production and sale of the minerals in that deposit. There is no strong direct relationship between the investment required to develop a mineral deposit and the time involved in developing that deposit. Nevertheless, in recent years the high cost of capital has resulted in the more rapid development of larger mineral properties in order to gain a quicker return on invested capital. This has resulted in an apparent negative correlation between the investment and the time involved in developing a mineral deposit. Despite this, the simple physical realities involved in developing large mineral deposits require a significant amount of time regardless of the effort put forth to hasten initial production. Since the 1860's the amount of money required to develop mineral deposits has increased substantially. Even since 1947 the amount of money required to develop some mineral deposits has increased significantly. At present, the expenditure of $100 million for the development of a mineral deposit is not uncommon. In the 1860's, $100 thousand was a substantial sum.

The amount of land required to develop a mineral deposit for the most part varies directly with the size of the deposit. The amount of land required, however, also varies according to the method of development and the type of mineral deposit involved. For orebodies with dominant vertical dimensions, much less land is required than for the same size orebody with relatively large horizontal dimensions. The amount of land required in mineral development is also closely related to the type and grade of mineral involved. For low-grade deposits that result in the production of substantial amounts of waste material, significantly greater amounts of land are required in the development of a mineral deposit for the preparation of waste storage facilities. Although land areas so required are not strictly involved in the mining operations themselves they are an absolute necessity in the production of the mineral commodity.

The land area required in mineral development does not appear to be related to the elapsed time of that development. Again, the nature of the mineral deposit and the effort put forth in development have a far greater effect on time. Similarly, the amount of land required is not directly related to the overall amount of the investment involved, although the costs of land acquisition and control are significant factors in determining the amount of investment made in the development of a mineral deposit. Nevertheless, other factors are of far greater importance in determining total investment, and any direct relationship between the amount of land required and the amount of investment involved is negligible.

In most cases, the development of a mineral deposit requires a minimum amount of reasonably assured mineral reserves. Before a substantial investment is made in the development of a mineral deposit, the potential minerals producer normally requires a reasonable degree of assurance that there will be sufficient value contained in the mineral deposit to return the cost of development plus a minimum profit. The necessary size of such minimum reserves, of course, varies according to the mineral being developed, the specific financial requirements of the potential producer, and the price that can be obtained upon sale of the mineral output. The amount of mineral reserves required for the development of a deposit of any one mineral commodity is usually directly related to the land area required. Over the wide range of all nonfuel minerals, however, the land area required for development and the amount of mineral reserves required are not directly related, primarily because some deposits have greater verticle dimensions while other deposits may have greater horizontal dimensions.

The development of a mineral deposit does not necessarily require an established market for the mineral involved. Most markets for metallic minerals are established, however, and

Table 6

REPRESENTATIVE MINE DEVELOPMENT COSTS IN THE UNITED STATES, 1947 - 1968

Mine (Ranked by Cost)	Commodity	Development Cost[a]
1	Lead	$19,000,000
2	Evaporite	5,000,000[b]
3	Lead	4,000,000
4	Sand	1,700,000
5	Iron	1,098,000
6	Potash	1,000,000
7	Uranium	510,000
8	Clay	415,000
9	Phosphate	400,000
10	Uranium	390,000
11	Uranium	286,000
12	Phosphate	200,000
13	Industrial Minerals	165,000
14	Uranium	75,000
15	Iron	70,000
16	Iron	50,000
17	Uranium	50,000
18	Salt	46,000
19	Phosphate	40,000
20	Limestone	28,000

[a] Cost from recognition as an orebody to first significant production.
[b] Largely pilot plant testing.

Source: Survey conducted by the Division of Economic and Business Research, The University of Arizona.

Table 7

SPATIAL REQUIREMENTS IN MINERAL DEPOSIT DEVELOPMENT IN THE UNITED STATES, 1947 - 1968

Property (Ranked by Area Used in Development)	Commodity	Total Area (in acres)	
		Involved in Development	Covered by the Orebody
1	Clay	30,000	24,000
2	Phosphate	6,400	8,000
3	Lead	5,000	500
4	Phosphate	2,500	1,000
5	Salt	2,500	500
6	Copper	800	600
7	Lead	800	800
8	Beryllium	800	800
9	Lead	500	500
10	Copper	500	500
11	Lead	400	400
12	Uranium	300	20
13	Sand	300	300
14	Uranium	210	80
15	Copper-Silver	200	100
16	Gold-Silver	160	80
17	Copper	150	150
18	Gypsum	120	2,560
19	Barite	100	80
20	Copper	100	100
21	Uranium	80	80
22	Copper	60	60
23	Limestone	46	46
24	Uranium	20	1
25	Uranium	20	5
26	Iron	20	4
27	Gypsum	10	1,920
28	Gypsum	10	1,280
29	Uranium	7	4
30	Uranium	5	4
31	Uranium	2	2

Source: Survey conducted by the Division of Economic and Business Research, The University of Arizona.

are national or international in scope. With regard to many industrial minerals, however, the existence of a *potential* market is all that is really required for the development of mineral deposit. The size of an existing or potential market for a mineral product is directly related to the size of the deposit being developed (or to the size of the portion of a particular deposit that may be developed at any one time). The size of an existing or potential market for a mineral product is also related directly to the size of the investment made in mineral deposit development in most instances, although there are exceptions based on the relative degrees of uncertainty involved. Similarly, the nature of the market for a mineral product, be it either existing or potential, is related directly to the time involved in mineral deposit development.

Where an established market exists prior to mineral deposit development there is a tendency for the time period of development to be shorter. Where the market is potential, however, there is a tendency for the time of development to be lengthened in some instances in anticipation of the growth of the market. On the other hand, there is often an offsetting tendency for the time of development to be shortened in order that the minerals producer may have a product available to aid in the cultivation or the full utilization of a potential market. The dominant tendency depends entirely upon the mineral commodity being developed. In some cases, a potential market cannot be cultivated at all until a finished product is available for sale. In other cases, the availability of the product will in fact create the market. In such instances it behooves the minerals producer to develop his property as rapidly as possible in order to take advantage of the potential market that can respond only to the availability of his product.

The nature and extent of the market for a particular mineral commodity are generally not related directly to the land area required for mineral deposit development. The geographic extent of a market is in fact relevant only as it influences the size of that market. It is the size of the market that is most important in determining the land area required for mineral deposit development through affecting the size of the deposit necessary for such development.

The characteristics of nonfuel minerals production in the United States have changed significantly since the 1860's. The changes that have occurred since 1947 have followed discernible trends which may be projected to 1985. The organizations and entities that produce nonfuel minerals in the United States have changed since the 1860's, since the early 1900's, and since the end of World War II. The methods and techniques used in mining nonfuel minerals have also changed since the late 1800's, the early 1900's, and the late 1940's, and they are likely to change again before the middle of the 1980's.

Probably the most important change in the methods and techniques used in mining nonfuel minerals since the 1860's has been the development of large-scale surface mining methods and the introduction in the West of large-scale underground caving methods. Since the 1920's, and particularly since 1947, the introduction of solution mining techniques and the increasing prominence in recent years of in-place leaching (as well as other leaching methods) are of vital concern to the utilization of land by the nonfuel mining industry. An increased use of solution mining techniques and in-place leaching can be expected by 1985 and the impact of this increase upon land utilization in mining can be expected to be significant.

Although most of the metallic minerals produced in the United States are now produced by large firms this is not true of industrial minerals output, particularly with respect to sand and gravel and other construction materials. In the production of such commodities, he small miner has retained a vital importance in the nonfuel minerals industry. Even in metallic minerals, the output of the small miner is still significant throughout the entire

Western United States, and although his contributions to overall national minerals output are relatively inconsequential, his contribution to local economic activity is highly significant. The small miner's greater worth, however, lies not so much in the volume of his mineral output, but in the volume of mineral resource information he provides and his development for the potential future utilization of mineral deposits by larger producers.

The methods and techniques of minerals beneficiation have changed drastically since the 1860's. The development of froth flotation was undoubtedly the greatest single factor in permitting the utilization of the large disseminated mineral deposits of the Western United States. Since the introduction of this process in the early 1900's there have been many refinements in both concentration and sizing operations in the minerals beneficiation stage of minerals production. Most of the changes since 1947 have been refinements of the same basic processes, and it is likely that this will continue to be the case until 1985.

The methods and techniques used in the advanced processing of nonfuel mineral commodities have likewise changed drastically since 1860. Again, however, since 1947 (except for the increased use of hydrometallurgical techniques) most of the changes that have been made in advanced processing have been refinements of the same basic metallurgical processes. With the exception of an expected increase in the use of hydrometallurgical methods, this same general trend may be expected to continue until 1985.

The methods and techniques used in nonfuel minerals production are highly dependent upon the particular mineral being produced. Mining methods are more dependent, however, upon the structure of the mineral deposit being utilized. In beneficiation and advanced processing, the nature of the particular mineral involved is of critical relevance.

The times involved in minerals production are dependent directly upon the methods and techniques used. Different phases of the production process involve different time spans depending somewhat upon the size of the deposit but more upon the particular mineral commodity and the type of mining, beneficiation, and advanced processing methods involved. Different minerals require different production cycles of different time lengths. These have changed since the late 1800's, and some have changed drastically since 1947. It is not expected that there will be any major changes in the length of the production cycle for most nonfuel mineral commodities by the middle of the 1980's. The principal exception to this is the possible lengthening of the production cycle involved in in-place leaching and the possible shortening of the production cycle involved in solution mining. Any changes in production cycles will vary considerably from one mineral commodity to another.

The costs of minerals production differs in each phase of the production process. It also varies considerably according to the methods and techniques of production used. Different minerals involve different costs of production. In general, low unit value minerals involve lower costs of production. There is a direct relationship between the cost of production and the value of the mineral being produced. This is not to say, however, the one is the cause of the other. In fact, there is normally a reciprocating cause and effect relationship involved. For example, as the unit value of a commodity rises it allows production from higher cost operations, thus resulting in a rise in the average cost of minerals production. Similarly, as costs rise, and if there are no alternative sources for a particular mineral product, then the market value of that commodity will also rise. Throughout history this has been a back-and-forth arrangement, with the value of the mineral commodity sometimes being the causal factor and the cost of production the effect, and at other times the cost of production has been the cause and the value of the mineral product the result. The unit costs of nonfuel mineral production have generally increased since the 1860's. There has been no consistent pattern since 1947, however, with new techniques and methods allowing cost reductions in the output of some commodities, but with other factors causing increases in the cost of producing others. This is likely to be the state of affairs at least until 1985, with some costs of production rising and other costs of production declining.

D. Why the Nonfuel Minerals are Important

The nonfuel minerals of the United States are principally important for themselves and not for the employment or personal income that they directly generate, nor for the government revenues which they contribute, although these are substantial. The nonfuel minerals industry in the nation as a whole is a relatively small employer, accounting for less than one percent of total United States employment in 1968. Regionally, however, the industry is a more important employer directly accounting for about two percent of total employment in the Western States. Locally, of course, the industry is even far more important, with many communities throughout the West dependent entirely or in large part upon the employment generated by the production of nonfuel minerals. In Arizona alone, six of the state's 14 counties are heavily dependent upon the mineral industry for their economic existence.

Because wages and salaries paid in the nonfuel mineral industries are generally higher than those paid in most other types of economic activity, the nonfuel mineral industries are of much greater importance as a source of personal income than as a source of employment. In addition, the personal income created by mining in the Western Region and in each of its communities recirculates a number of times, thereby, generating additional personal income that has a significant impact upon the entire Western United States.

In many of the Western States the nonfuel mineral industries provide a significant share of government revenues both at the state and local levels. In many Western States, substantial portions of government revenues result from taxes placed upon mineral utilization activities. At local levels, the property taxes paid by mineral industry operations are a vital factor in many communities. Nevertheless, the amounts of money spent by state and local governments for the benefit of mineral utilization are relatively slight and consist primarily of the expenditures of regulatory agencies and some technical assistance agencies. The nonfuel mineral industries also contribute substantially to federal revenues, primarily through corporate income taxes. Nevertheless, the federal government spends a relatively small amount (mostly through the Department of the Interior) for the benefit of nonfuel minerals utilization.

Despite direct and indirect contributions to personal income and governmental revenues, the greatest contribution of nonfuel minerals to the economic life of the nation and the Western States has been as vital commodities. The metals mined in the United States form a critical part of the nation's industrial structure. Without copper, steel, lead, silver, and other metals mined domestically, very little of today's complex machinery would be able to function. Without some of the metals neither the ordinary complexities of every day industrial life nor the hypercomplexities of aerospace and electronics age activities would be possible.

The importance of the country's industrial minerals has been even more direct, particularly in the West. Many of the industrial minerals mined in the Western States provide materials for the construction that has been vital in the economic development of that region. Other industrial minerals have provided fertilizers and have been important in the development of agriculture throughout the United States and the World. Minerals produced in the Western United States have also been important in the industrial growth of nations in the Pacific Basin and they played a principal role in the industrial resurgence of postwar Japan.

E. How Nonfuel Minerals are Related to Other Resources

There has long been a significant relationship between minerals resource utilization and the utilization of nearby water resources. Data are not available, however, to determine quantitatively whether there has been any significant change in the volume of water utilization by the mineral industries since the 1860's or even since 1947. Since the latter part of the last century, however, the nature of water use by the nonfuel mineral industries has changed, primarily as a result of the significant decrease of placer mining in the United States.

Water use is different for each phase of the minerals production process, and is dependent upon the technology of production. At the present time, minerals beneficiation processes are the largest users of water in the mineral industries. Mining operations themselves are relatively small users of water, although the increasing importance of leaching has increased water utilization in mining. Nevertheless, even in leaching operations the water involved is normally used in closed circuit so that actual consumption is minimized.

Water utilization by the mineral industries is directly influenced by the scale of production, with more water being used by larger operations. The production of different minerals also involves different water requirements. The commodity differences are normally directly related to the technologies involved in the processing of different mineral commodities. Data for the late 1950's and 1960's indicate that water utilization by the mineral industries is relatively slight compared to overall industrial and agricultural use. This does not hold true for specific localities, however, where a single operation of a mineral producer may be an important user of water resources. Water utilization by the nonfuel mineral industries varies according to the locale in which situated. A number of factors, including climate, water availability, and cost of water seem to determine this water use variation according to location.

Liquid waste management practices in the nonfuel minerals industry have changed considerably since the 1860's. No longer are the liquid wastes created by minerals production operations allowed to be indiscriminately returned to the physical environment. Since the early 1900's it has been the practice to return most liquid wastes resulting from producing operations to the environment by means of evaporation or seepage from tailings ponds. Very small amounts of liquid wastes are now returned to active streams by nonfuel minerals producers in the Western United States.

By 1985 it is expected that even more care will be taken in preventing liquid wastes from having harmful affects upon the surface water environment. This will be true not only because of expected legal restrictions but even more because of the increasing cost of fresh water and the resultant increased advantage in the repeated utilization of liquid wastes within the minerals production process.

Liquid waste management practices differ in each phase of the minerals production process. There is relatively little liquid waste produced from mining operations, even from high water-using leaching operations where the liquid effluents created are not waste at all but contain the product. In beneficiation and advanced processing operations, liquid wastes are usually much more significant, with the greatest amount created by beneficiation operations. In beneficiation, however, liquid wastes are normally used in the transportation of solid wastes and are returned to the environment only by evaporation or slow seepage to groundwater.

Liquid waste management practices in minerals production are directly dependent upon the technology of production used. They are also dependent upon the nature of the commodity being produced, but the technology of production is far more important. Differing liquid waste management practices require different land areas where aqueous wastes are returned to the environment by evaporation. A larger land area than would otherwise be required is needed to permit a maximum evaporation rate. Minimum land areas are required where liquid wastes are discharged directly to active streams.

Solid waste management practices in the nonfuel mineral industries have changed relatively little since the 1860's and they are not likely to change very much by 1985. Solid waste management practices differ slightly in each phase of the production process, and they are dependent to a certain extent upon the production technology in use. Solid waste management practices are also dependent upon the nature of the commodity being produced with the storage problem increased by the utilization of lower grade material. In general, solid waste management practice in the nonfuel mineral industries involves storing solid wastes on land that is not expected to have a valuable mineral deposit beneath it. The greater the scale of production and the lower the grade of the mineral being utilized, the larger the area normally required for solid waste storage.

Solid waste management practices also differ according to the location of the particular mineral producing operation. Where surface area is scarce and valuable, there is normally an attempt made to utilize the surface of waste storage areas for other purposes. In remote areas, however, where land is relatively less valuable, there is comparatively less effort made toward multiple use of that surface area used initially for solid waste storage. Waste management practices in mineral production thus depend heavily upon the surface value of the land in the vicinity of the mineral property.

The production of nonfuel minerals requires a certain amount of land area for any given mineral deposit. The amount of land required varies for each phase of the production process although there are strong similarities between the land requirements of the beneficiation process and the land requirements of the advanced processing stage. Each of these normally require much less land than the land requirement for actual mining operations, except for waste storage needs. This is not necessarily a consistent relationship, however, the significant exception being the production of sulphur where the land requirement for mining is relatively small but where the beneficiation and advanced processing plant require a far greater surface area.

The amount of land required for minerals production depends most upon the technology used. Open pit mining generally requires a greater surface area than underground mining, and underground mining may require a significantly greater amount of surface area if it involves a caving operation than if it does not involve any surface subsidence. Similarly, solution mining not resulting in surface subsidence may require even less land than underground mining. The amount of land required for mineral production also varies with the type of mineral being produced, but more importantly with the type of mineral deposit in which that mineral is found. Thus both molybdenum and copper deposits of similar structural characteristics will have essentially the same land requirements, but two copper deposits, one of a large disseminated nature and the other of a vein or bedded replacement nature will have different land requirements. The amount of land required for the production of a mineral is related directly to the size of the mineral deposit being worked and most closely to the lateral dimensions of that deposit. In some cases where caving or overburden stripping angles must be maintained, the vertical dimension of the mineral deposit is also directly related to the surface area required for its mining. The amount of land required for mineral production is further influenced directly by the scale of production involved. This is particularly true of low-grade deposits where the scale of production directly affects the amount of waste material that must be stored. These general relationships have not changed since 1947 nor are they likely to change by 1985. Throughout the next 15 to 20 years it will probably be generally true that the greater the lateral extent of a mineral deposit and the greater the volume of production from that deposit, the greater will be the land area required for its utilization.

Gaseous waste management practices in the nonfuel mineral industries have changed, particularly since 1947. Air pollution control measures have become much more prevalent as both legal and economic conditions have changed. As a result, there has been a substantial change in the gaseous waste management practices of the nonfuel mineral industries since the late 1800's. These are likely to change further by 1985.

Gaseous waste management practices differ significantly in each phase of the minerals production process. There is relatively little gaseous waste created by mining and beneficiation operations. Most gaseous waste products created by the nonfuel minerals industry result from the advanced processing stage of production. Their volume and nature differ according to the production methods and techniques in use, the scale of production, and the nature of the mineral commodity being produced. The advanced processing of sulfide ores, for example, yields sulfur oxides as gaseous wastes, and similarly, the production of phosphate minerals containing flourides results in the production of flouride gas as waste. The gaseous waste management practices followed by the nonfuel minerals industries are determined directly by the nature of the waste itself. Where the waste product can be used to produce another valuable commodity (such as in the case of the production of sulfuric acid from the sulfur oxides contained in smelter gases) gaseous waste management practices are also affected.

II. EXISTING MINERAL LAND SYSTEMS

A. Non-Federal Mineral Land Systems

The terms and conditions of mineral tenure on non-federal lands in the United States vary widely. This is true of state-owned lands as well as privately held lands in both the Eastern and Western States. These variations are the result of many factors. Present terms and conditions of mineral tenure on state-owned lands vary from state to state, in part according to the nature of the original status of the land. The terms and conditions of state mineral land tenure in the public domain states often differ in some significant way from those in areas where state lands were not part of the original public domain. The similarities from state to state are much greater than the differences, however.

There are different methods of title transfer used in non-federal mineral land systems. Under state land systems, the variation is minimal, with all state mineral lands falling under leasing systems, regardless of the particular nomenclature used. Under private land systems, however, the variations in the means of title transfer are enormous, ranging from outright sale of land through various option systems to straight leasing arrangements or sales of mineral output only.

The size of the land area involved in non-federal land systems also varies considerably throughout the United States. Under state land systems there are some minima of 10 acres established, with increments of 10 or 20 acres allowing area variations up to several thousand acres. Under private land systems, the variation in acreages involved is almost continuous, extending from very small amounts (less than an acre) up to very large tracts measuring in the thousands of acres. The length of mineral land tenure likewise varies considerably under private land systems. For state mineral lands, variation runs from 30 days up to almost continuous tenure as long as certain conditions are met. Tenure varies, however, depending upon the use being put to the state mineral land – whether it be used for exploration, development, or for actual production. Tenure under exploration is much less certain and for shorter time periods than under most production operations. The same is essentially true of private land systems in the United States. Under private land systems, short time increments (of several months to several years) are common, although most arrangements are renewable, with some time of option involved.

There are numerous means of payment made for mineral lands under private land systems. Under most state land systems, payment is made through a royalty during the production stage of operations, with minimal rental fees involved during the exploration phase. Under private land systems, the variations in the means of payment are far greater. Royalties are common. Land rentals are also used, as are outright purchase payments, option fees, and stock payments, as well as production payments in advance. Most such arrangements are now determined largely by tax considerations.

Under most private land systems, performance requirements are also quite variable. The variation is minimal under state land systems, with most states requiring only nominal performance in order to obtain a mineral land lease. Under private land systems, the performance requirements involved are usually more specific and adjusted to the particular mineral property involved. They are also usually much greater and designed to actively encourage performance by the minerals producer and avoid the holding of excessive amounts of mineral land at a minimum cost simply for speculative purposes.

Under many existing non-public land systems, the former owners (including state governments) of the mineral lands retain their interests in these lands. In all of the state land systems, the state retains at least a royalty interest in its mineral resources, even where lands are leased for extremely long terms. Under many private land arrangements, the previous individual or corporate owner of the land also retains an interest in the mineral land either through royalties, land rental payments, or participation in earnings. The precise method by which interest is retained in mineral land varies considerably under most private land systems and is usually adjusted to meet the specific conditions found at each mineral property. Outright sale of mineral properties has become less common although lease-purchase arrangements are widely used.

In most private land systems in the United States (including state land systems), payments in lieu of work are not usually found. Under most private land systems, requirements concerning environmental effects have likewise been uncommon. Under state land systems, however, such requirements are frequently used, particularly in the East and other more densely inhabited portions of the country. In the Western States, environmental control requirements are still relatively uncommon.

Throughout most of the United States, provisions regarding nonfuel minerals exploration, development, and production on non-federal lands vary according to the specific commodity involved. Under most state land systems, commodities are roughly grouped, and the various system features relevant to exploration, development, and production vary according to the group in which a particular mineral commodity falls. In most states, the grouping of commodities and the resulting differences in state mineral land system provisions are based on the principal physical and/or economic characteristics of the minerals involved. In several states, such as Minnesota, tradition has been the dominant factor in the classification of mineral commodities.

Although most mineral tenure arrangements on non-federal lands in the United States contain provisions for the renewal and subsequent renegotiation of lease arrangements, mineral tenure agreements on non-federal lands generally do not provide discretionary rights to change the terms and conditions of an agreement during its life. Renewal arrangements, however, set specific intervals at which such items as rentals, royalties, methods of operation, and other significant features of the mineral tenure agreement can be changed upon mutual agreement of the contracting parties. This is true under most state land systems as well as under private land systems.

B. The Existing Public Land Systems

The search for and the utilization of nonfuel mineral resources on the public lands of the United States are currently conducted under one or more of three distinct land systems. The first is a *mining claim location system,* adopted in the 1860's and 1870's from the local rules and practice developed in the various mining districts of the West. The second is a *minerals leasing system,* developed in the early 1900's, essentially for the fuel minerals and for specific industrial minerals (i.e., potash, phosphates, sodium salts, and sulfur) that have national markets. The third system is a *mineral commodities disposal system,* involving the discretionary sale or grant of specified industrial minerals. This last system was developed in the 1940's and 1950's.

Under the location system as established by the Mining Act of 1872, mining claims of a given maximum size (about 20 acres) may be located upon the public domain. These may be either *lode claims* or *placer claims,* depending upon the character of the mineral deposit claimed. There are no limits on the number of claims that one person may locate. There are also provisions for five-acre *mill sites* and *tunnel sites.* The system, as originally established, provides that upon completion of a specified amount of *discovery* work, upon proof of a valid mineral *discovery,* and upon payment of a patenting fee ($5.00 per acre for lode claims and $2.50 per acre for placer claims), then title to the land and its minerals is transferred to the mineral claim locator. There have been subsequent modifications of this both by legislation and by administrative and judicial action.

Under the various laws that define the existing leasing system, there are provisions for *prospecting permits* and both *preference right leases* and *competitive leases* on public lands that have been designated as primarily valuable for the production of potash, phosphates, sodium minerals, or sulfur. The system is administered by both the Bureau of Land Management and the Geological Survey. There are provisions for filing fees, land rentals, royalties, and bonus payments (in the case of competitive leasing). The features of the system vary somewhat depending upon the mineral commodity involved, the state in which situated, and whether the land involved is original public domain or has been acquired.

The minerals disposal system provides for the sale or grant from public lands of the so-called *common varieties* of certain minerals used primarily in construction and not specifically included in the location or leasing systems. Most substantial sales are made by competitive bid, and no transfers of land title are involved. Basically, the system (for a price) allows the purchaser of mineral materials to remove designated minerals from a specified portion of the public lands during a specific period of time. The system is administered by both the Bureau of Land Management and the Forest Service.

Although there have been certain strong points in each of the three systems, the weaknesses of the existing public land minerals systems are many. A number of these weaknesses arise from the multitude of legislation applicable to the mineral resources of the public lands and from the wide variations in the treatment of mineral problems and issues on the public lands through various pieces of legislation, judicial decisions, and the regulations of various agencies.

There are many other weaknesses in the existing system caused by severe inconsistencies between the law and geologic, technical, and economic reality. Many of these weaknesses are found within the minerals location system. These largely result from the fact that the system was developed initially in the 1860's and 1870's as appropriate to the mining of gold, silver, and mercury from placer and relatively small vein deposits in the western mountains and valleys. Basically, the law has not been adapted to meet changing conditions in the nonfuel minerals industry. In fact, virtually the only adaptation that has been made as a concession to modern technology has been the recent change in the laws of several states allowing diamond drill holes to be substituted for the previously required discovery pits. Diamond drills were in widespread use in minerals exploration before World War I. (See Chapter 7 of the basic report.)

In the minerals leasing system, the primary weaknesses are the result of inconsistencies between the law and economic reality, with perhaps the most serious of these resulting from erroneous concepts involving the maximization of current federal revenue and land reclamation. In the commodity disposal system, the most serious weakness is the fact that the system employs the concept of *common varieties*. This concept and several others in use throughout the entire mineral land system (including *discovery, nonmineral land,* and the distinctions between *metallic* and *nonmetallic* minerals) are seriously inconsistent with geologic and physical reality. As such, they form a serious weakness in the entire public land system for minerals.

Other major system weaknesses have arisen from the administrative procedures and policies followed by the Department of the Interior and the Department of Agriculture. In many respects, these weaknesses appear to have developed because of discrepancies between the intent of the Congress in enacting mineral land legislation and the intent of the Executive Branch department responsible for the administration of the laws. In balance, the weaknesses of all three existing public mineral lands systems currently in operation in the United States are far greater than the strengths of those systems. These is little doubt that changes must be made.

The combined weaknesses and strengths of the existing systems under which the search for and utilization of nonfuel minerals on the public lands of the United States must take place have resulted in a number of major issues regarding public land mineral policy. The first of these issues is basic to the entire problem and involves the decision to treat all public land minerals under a single comprehensive piece of legislation or to deal with the issues on a piecemeal basis. This concerns all of the various distinctions that have been made in the past on the basis of commodity, state, nature of original title (i.e., public domain or acquired), and the agency responsible for surface supervision. It also concerns the problem of how specific to make such legislation and whether or not all or some of the judicial doctrines established over the past 100 years should be made part of the statute law.

The second vital issue involves the attitude of the federal government towards its status as owner or trustee of the mineral resources of the public lands and its position as sovereign, landlord, or representative of the people of the United States. The position taken will directly influence the basic decision as to whether title to the mineral resources on the public lands should be transferred to the private sector, transferred to state or local government, or retained by the federal government. This also involves a decision regarding the exclusion of minerals exploration, development, and production from certain public lands and the basics on which such exclusion (if any) should be made.

Such a decision involves a number of other issues. If it is determined that minerals should be utilized principally by the private sector, then there must be a decision as to whether mineral rights should be transferred from the federal government by means of a claim and patent system, by a leasing system, by a sale of land, minerals, or both, or by some combination of methods. Also requiring resolution in this respect is the issue created by the severance of mineral rights from surface rights. It must be determined whether minerals will be severed from surface rights, and if so, in what manner and under what circumstances. Furthermore, the issue of disposal or retention of existing mineral rights reserved to the federal government must be considered.

Closely related to the general issue of method of transfer of mineral rights from the public to the private sector is the more specific issue of payment for those rights. There must be a decision as to whether such payment should be nominal, designed to encourage (or restrict) mineral resource utilization; based upon surface land values or based upon some attempt to appraise the value of minerals in place. (See Chapter 5 of the basic report.)

Particularly within the last three decades, the issue of federal agency jurisdiction has become of ever increasing concern. The entire issue involves several critical decisions. It must be decided whether one agency or several shall be responsible for the administration of minerals policy on the public lands. The extent of the discretionary authority given to such agency or agencies must also be determined.

III. ALTERNATIVE PUBLIC LAND SYSTEMS

A. Criteria and Dimensions

There are, of course, a number of alternatives to existing public land minerals policy, and these alternatives would have differing effects on the utilization of the nation's nonfuel mineral resources. In judging these alternatives certain criteria may be used. The provisions of any system should most certainly reflect a recognition of the physical realities of nonfuel mineral occurrence and utilization. They should also reflect a recognition of economic realities. Furthermore, any legal system must be capable of effective administration and its effects on existing institutional structures must be recognized. It goes almost without saying that any alternative system must also reflect a recognition of political realities.

Nearly any alternative system (or specific system feature) for public land minerals may be grouped into one of several broad categories as determined by two basic dimensions. One of these dimensions extends from government ownership and control at one extreme to private enterprise at the other. The other dimension ranges from monopoly to competition. Any feature of any public land system may be measured along the continuum provided by those two dimensions.

Any alternative system developed with respect to public land minerals must also treat a number of essential variables. The first of these involves *tenure status,* ownership or leasehold, and whether by the federal government, other governments, land speculators, or *bona fide* minerals producers. The second variable concerns the *processes of minerals utilization,* exploration, development, and production, and whether they are to be treated separately or grouped. A third variable is *geographic,* and it is one of the most important variables to be considered for it is the very nature of the subject. Lands of one type or in one place may be distinguished from others or all (or some) may be considered alike.

Agency considerations form a fourth variable of any public land system since the law must be administered, be it by one agency or many. The various mineral *commodities* form a fifth variable, and they may be treated individually, all alike, or grouped. *Money* provides another variable to any alternative system and constitutes an extremely flexible and complex feature. *Time* is likewise a highly adjustable variable in any mineral land system. Similarly, *space* considerations may be extended through a wide range of minima, maxima, and incremental amounts.

Both the specific *obligations* and *rights of the federal government* provide additional variables to any alternative system. The same is true of the *obligations* and *rights of the mineral resource user.* Various combinations of all of these variables present a wide range of possible alternative systems and features.

B. One Public Lands Mineral Law

One of the principal alternatives to the existing public lands mineral system would be the enactment of a single law concerning all mineral-related matters on the public lands. The most all-inclusive version of this alternative would contain provisions relevant to all subsurface resources, including subsurface water. Within the assigned jurisdiction of this study, however, the extreme alternatives considered would encompass only nonfuel minerals. The alternative would involve repeal of all existing legislation that has been detailed in the legal study of the nonfuel mineral resources by Twitty, Sievwright, and Mills and would replace the existing collection of such laws with a single nonfuel mineral law pertaining to the public lands and with sufficient specific detail to avoid the need for enabling legislation in the various states.

The implications of this alternative are numerous. The federal administration of the public land law would be greatly simplified as a result of the replacing of numerous separate items of legislation with a single law. It is true, of course, that the many court decisions and administrative regulations that have been formulated in conjunction with the administration of existing legislation would no longer be valid but could be incorporated in any new law. Nonetheless a law could be written so that those portions of the existing judicial and administrative law considered desirable could be explicitly incorporated into the new legislation. Furthermore, it would probably not be long before new court contests would arise to establish a new set of judicial decisions, and there is no doubt that administrators within the federal government would very quickly establish new sets of administrative rules and policies.

A single federal minerals law would have implications for state and local governments, as well as for the federal government. The impact of a single federal minerals law for public lands would probably be felt most at the state level. Such a law, if made specific enough (and depending on its features), could in effect nullify the various state laws regarding the acquisition of mineral resources on the public lands and restrict their application only to lands actually owned by the states or other appropriate local jurisdictions.

The effects on the economic environment of a single federal minerals law would depend primarily on the actual provisions of that law. Such a law could, of course, simplify government procedures and thereby lower government costs, and as such it would have a definite impact upon the public sector of the nation's economy. The impact on the regional economy of the West, and the numerous local economies would also depend upon the specific provisions of the single law. The same would be true of the effects of a single law upon the physical and social environments in which nonfuel mineral resources are utilized. The same could be said of the effects on the relationships between mineral resource users and other resource users on the public lands.

The effects of a single minerals law upon the minerals industries themselves would be essentially twofold. First, the major effect would be to simplify mineral acquisition and eliminate the need for determining what is a locatable and what is a leaseable mineral. Having a single mineral law, however, would not necessarily mean that the distinction between locatable and leaseable minerals would be obliterated. If it were, in fact, felt desirable to maintain this distinction because of certain characteristics that were considered valid (at least at one time) as criteria for such distinction, then they could be incorporated into a single law. The essential effect of the one piece of legislation would be to simplify and (hopefully) eliminate some of the inconsistencies that presently exist between laws dealing with different minerals that were enacted at different times for different purposes. The greatest impact of a single law on the mineral industries would, however, depend upon the more specific provisions of that law. Simply the establishment of one law in place of many would not necessarily change the major provisions of those laws.

The effects of a single minerals law on the mineral resources of the public lands themselves would likewise depend upon the specific provisions of that law. The considerations of all minerals under a single piece of legislation, however, would be a significant step in the direction of making the law consistent with geologic reality.

There are, of course, possible variations of this alternative. One of these is to leave much as they are the collection of miscellaneous laws that are now in existence. This would leave one law dealing with *locatable* minerals, one law dealing with *leaseable* minerals, one law dealing with materials disposal, and various other laws dealing with relatively minor facets of public land minerals policy. The implications of this should be rather obvious. They would perpetuate the existing inconsistency between the law and geologic, technical, and economic realities, and they would continue the administrative confusion, overlap, and inconsistencies that now exist.

In the other direction, the placement of all minerals and subsurface waters (in effect all subsurface resources) under one public land law for subsurface resources would perhaps be somewhat extreme. There are real differences between those subsurface commodities, such as water, oil, gas, steam, and helium, which can flow from the site of their original location to another point without regard to property lines or political boundaries and those minerals which are normally found in a solid state. Perhaps inclusion of all of the *flowable* minerals with the *hard* minerals under a single law would be a step away from the needed consistency between the law and geologic reality. The inclusion of dissimilar problems and dissimilar commodities under a single piece of legislation could, rather than simplifying administrative procedures, further complicate and obscure them.

The principal result of the establishment of a single public land minerals law, at least for most nonfuels and coal (or at least for most of the hard minerals), would be the simplification of federal administrative procedures and the facilitation of mineral resource use. Further effects would depend entirely upon the specific provisions of that law.

C. Disposition of Mineral Rights Now in the Public Domain

Probably the most basic question involved in the utilization of mineral resources in the public domain involves whether or not these minerals should be subject to disposition, management, or retention. One alternative to existing policy and law would be to have all mineral rights presently severed from surface rights and reserved to the federal government sold to the owner of the surface rights. This alternative would deal directly with the existing and potential problems caused by the severance of surface rights from mineral rights on lands, the surface rights to which have left the public domain. One logical alternative would involve the sale of mineral rights to existing surface owners for a nominal sum, perhaps equivalent to or less than the existing $5.00 per acre involved in the patenting of claims, or less. A logical second step in this alternative is that mineral and surface rights hereafter would not be severed, as far as the federal government were concerned. In other words, those individuals or firms receiving title to mineral rights on the public lands would also receive title to the surface rights. Similarly, those firms or individuals receiving title to the surface rights hereafter would also receive title to the mineral rights beneath that surface.

Such a practice, if adopted, would immediately lead to the removal from the public domain of large areas of presently reserved mineral rights situated underneath privately owned surface lands throughout the 11 Western States. A problem could arise, however, where the surface owners of large areas would not want to pay for the mineral rights under their large areas, because even a nominal per acre sum could become a substantial amount, if multiplied by enough acres. In such a case it might be well to develop a sliding scale of fees or perhaps introduce an even smaller fee than the $2.50 an acre now involved in mineral patents.

The implications for the federal government of this alternative would be several. First, the sale of mineral rights would bring an immediate increase in revenue to the federal government. Over the longer run, however, the direct effect would be a reduction in the income received from the leasing of federally owned minerals now held under private surface land. Another impact on the federal administration of public land minerals would be a simplification of that administration in that the law would apply hereafter to areas in which both surface and mineral rights were owned by the federal government, and the problems arising from distinctions between surface owners and federal ownership of the subsurface would be eliminated.

The impact of the alternative on state and local government would be generally beneficial and would be similar to the effect on private owners of the surface land. In many respects, the various state governments would become the owners of significant areas of mineral resources now located underneath areas on which the states own the surface rights but do not own the mineral rights. For many local governments and for state governments as well, the alternative would mean an increase in the tax base, because of the addition to total real property of the mineral resources presently reserved to the federal government.

The effects of this alternative on the national economy would be difficult to measure, but they would be felt primarily through the public sector. First, there would be an increase in immediate governmental revenue caused by the sale of subsurface resources. Second, there would be a decrease in the income received from mineral leasing. There would also be secondary economic effects, however, caused primarily by the reduction in size of the areas open to minerals exploration and acquisition under either public land location or leasing procedures. Such an impact might be far more widespread and significant than the immediate impact through public sector revenues. This would also be the case for the effect of this alternative on state and local economies. Although the tax bases of such local economies would immediately increase, and public revenues would be increased in the short-term, the reduction in the amount of public land available for minerals acquisition through the location and leasing procedures could have an adverse effect on total mineral resource development, and thus restrict development in many of the local economies of the West. This, of course, would also have a long-term adverse effect upon state and local public revenues.

The influences of this alternative upon the physical and social environment would be various. In most respects this alternative would eliminate any control by the federal government over the direct effects on the nonmineral environment caused by mineral resource users, at least through the public land laws. This is not to say, however, that environmental controls could not be exercised through other means such as specific air or water pollution legislation. Such a distinction would probably be advantageous for the government, the public, and natural resource users alike, in that there would be no mingling of purposes within the same law. The effects of this alternative on nonmineral resource users of the public lands would probably be negligible, particularly in areas where other resources already have had access to the surface. It would most certainly eliminate much of the potential conflict between mineral resource users and surface owners in those areas where subsurface and surface rights have been severed. Although this has not been serious to date, the problem potential, particularly in the urbanized areas of many Western States, is very real and perhaps more immediate than is realized.

The effects of this alternative on the mineral industries now operating on the public lands would be to restrict the areas under which they could acquire new mineral resources under either the location or leasing procedures of existing public land mineral law. It would, in effect, place greater mineral areas into the private sector and could increase the problems of future mineral resource acquisition for minerals producers. On the other hand, for those firms or individuals later acquiring mineral resources from the public lands, it would make available to them complete ownership of the surface as well and thereby considerably simplify many of the problems that now exist with unpatented mining claims and in mining on land where the surface is still controlled by the federal government.

The effect on the alternative on mineral resources would be similar to that on the mineral industries that are or would be utilizing those resources. Probably the greatest impact would be the reduction in potential mineral reserves because of the decrease in accessibility to those reserves caused by placing them under private ownership. In many areas of the West, this would duplicate the situation now found in the non-public areas of the remainder of the United States, where it has become increasingly difficult to acquire potential mineral lands (even for exploration) at a reasonable price. This could have serious consequences for the economy of the nation as a whole.

There are, of course, variations to this alternative. One of these is that all mineral rights hereafter would be reserved to the federal government regardless of the disposition of the surface rights of the public domain. This alternative would, of itself, not eliminate any of the problems caused by existing or potential conflicts between mineral resource users and other users of the surface rights presently held under private ownership. It would, however, guarantee access to the maximum extent of mineral resources currently held in the public domain.

A third variation of this alternative would be to consider ownership rights to public land in terms of depth rather than content. In other words, mineral rights as such would not be involved, but those present surface owners might have to receive title to all rights down to a certain depth, say 1,000 feet or 5,000 feet below the original surface. Hereafter, even if mineral rights were disposed of separately, they could include a vertical dimension, rather than simply area and commodity dimensions. Such a variation might be more consistent with geologic and technical reality in dealing with the conflicts that could come about between users of mineral resources and users of the surface. Most mineral deposits below 1,000 feet from the surface would probably have to be removed by underground mining methods or other methods involving a minimum disturbance of the surface, whereas deposits within 1,000 feet of the surface can now normally be removed by surface mining methods which also remove the previous surface. Where the surface is highly irregular, however, this designation of a depth dimension could be problematical. Then too, it could cause a restriction in the access to near-surface deposits of certain minerals and could place increased emphasis on underground or solution mining techniques. It could also, however, seriously restrict the use of any caving methods of underground mining or other subsurface techniques which result in surface disturbance.

The attachment of surface rights to the acquisition of mineral rights from the public domain would eliminate, in many respects, the problem of unpatented, abandoned mining claims. Once mineral activities had ceased, the surface land would still belong to the person or firm who had acquired it for mineral purposes, to be used in any other manner consistent with other legislation. This property would be taxable and as such, any abandonment could be cleared by due process of law under local procedures for nonpayment of taxes.

It would appear that the most logical variation of this alternative would be that: (1) hereafter, those who acquire mineral rights from the public domain also acquire the surface rights in fee simple; but (2) those who presently have only surface rights where mineral rights have been reserved to the federal government should not receive the mineral rights except for explicit and immediate minerals development. This combination of features would result in a maximum amount of mineral resources open to acquisition by mineral resource users, while at the same time eliminating many of the problems caused by the abandonment of exhausted mineral properties and the resultant problems arising from unclear titles to unpatented mining claims.

D. Unrestricted Minerals Reconnaissance on the Public Domain

This alternative procedure would allow mineral reconnaissance over all public lands without any restrictions except those that might be involved in the disturbance of prior surface usage where such uses are specific private or restricted special uses by the federal government. Such government uses would include sites for public buildings, national defense installations, atomic energy test sites, hydroelectric sites, and national parks and monuments. This alternative would permit what is, in any respects, already being done by air. It would also permit on-site geologic reconnaissance, but not detailed exploration. In other words, it would permit individuals searching for mineral resources to walk, ride, or fly over the public domain in search of surface mineral indications. Coupled with this free access to the public lands for mineral reconnaissance purposes, however, would be an absence of any prediscovery protection or preferential rights to those minerals for which surface indications or aerial geophysical indications might be found.

The implications of this alternative for the federal agencies responsible for the administration of the public lands are several. Such a provision in the mineral law would serve to open up many areas for minerals reconnaissance that are now closed or withdrawn from such activity. This would undoubtedly have an impact upon those agencies directly responsible for the administration of those areas. The law would also specifically define those areas closed to minerals reconnaissance, but in doing so it would probably be necessary to provide justifiable reasons for restricting personal access to such areas. The specific elimination of any prediscovery rights resulting from reconnaissance activities would also enhance judicial processes, particularly with respect to the handling of litigation by conflicting claimants.

The impact of this alternative on state and local governments is difficult to estimate. Direct effects would probably be nil. Indirect influences would probably be considerably greater, in that larger areas of the public lands would be open to minerals reconnaissance, and economic activity within the jurisdictions of various state and local governments would be increased. This would be the major impact on the regional economic environment as well. A longer term effect would result from the fact that greater amounts of mineral resources would be opened, not necessarily to physical acquisition by minerals producers, but at least to their acquaintance. The stimulation of reconnaissance activity in certain areas would have a definite, although probably a relatively small impact upon local economies in those regions.

The effects on the physical and social environment of permitting free access for minerals reconnaissance purpose to all areas of the public lands except those actually used by the government for specific government function would probably be negligible. There is virtually no effect on the environment from an airplane towing a magnetometer flying over a wilderness area. Nor is there much impact one way or another from the boots of a field geologist striding over open areas of a national park or wilderness area. With modern techniques, the effects on the physical environment of geophysical and geochemical surveys are literally almost unmeasurable without specialized instruments. They are certainly insignificant when compared to the effects of other public land activities. It should be borne in mind that, without any prediscovery protection, minerals reconnaissance activity would, of economic necessity, be kept to a bare minimum. As a result the effect on nonmineral users of the public lands would also be minimal.

The primary effect of this open reconnaissance alternative on the mineral industries would be to increase the areas available for preliminary minerals exploration and, therefore, to increase the nation's potentially available mineral resources. For such an alternative feature to provide any really effective spur to increasing mineral exploration activity, however, it would have to be coupled with an opportunity for acquiring prediscovery rights toward any anomalies that might be encountered and a subsequent opportunity to develop and use any valuable mineral deposits discovered. As far as the mineral resources themselves are concerned, the alternative would considerably increase the potential mineral resources of the United States. The feature would most certainly bring the provisions of the mineral law and policy on the public lands in much closer conformity with both technical and geologic reality. Economic reality would in turn minimize any tendency toward adverse effects that might result from the operation of this policy.

E. Detailed Minerals Exploration Under Franchise

Under this alternative, detailed minerals exploration (including target area examination and mineral deposits evaluation) would be permitted on the public lands under an exclusive exploration franchise designated for a specific area for a specific period of time. Any franchise would be awarded on a first-come, first-served basis for a minimal per acre fee. For the subsequent utilization of any mineral resources discovered under an exploration franchise, preference would be given to the current franchise holder.

The procedure used in this alternative would require any individual or firm interested in the detailed exploration of a specific public land area to apply for a detailed exploration franchise for that area. The franchise would be for a specific period of time, probably from one to two years, and renewable for additional periods of from one to two years. It would be necessary for the holder of an exploration franchise to perform a certain amount of detailed exploration work (measured in dollar terms) within the designated franchise area within six months of the awarding of the franchise or relinquish it. Subsequently, additional amounts of work would be required. The holder of an exploration franchise would be required to control any possible detrimental effects of his activities upon the natural environment. All basic (but uninterpreted) information about the franchised public land area obtained by the holder of an exploration franchise would be made available to the federal government upon termination of the franchise. The holder of an exploration franchise would be required to permit access to the franchise area by other users of the public lands, so long as public safety and the security of personal property would permit. The holder of an exploration franchise would also be allowed to remove minor amounts of mineral commodities from the public lands designated in the franchise for testing purposes, but not for sale.

Any exploration franchise would involve all minerals. The maximum contiguous area initially involved in any one exploration franchise would be five townships, and there would be a fixed though minimal per acre fee for this amount. Under the alternative, it would be necessary for the franchise holder to reduce the area of the franchise every year. For example, after one year it would be necessary to reduce the franchise to a maximum of five contiguous sections. As the area is reduced, the per-acre franchise fee would be increased in order to prevent excessive speculative holding under any one exploration franchise. Upon each franchise renewal date, the amount to be paid per acre would be increased, even without area reduction for a five-year exploration period maximum. This would allow a legitimate minerals exploration firm to concentrate its effort on its most likely exploration target and begin intensive mineral deposit evaluation. Any exploration franchise area would be in multiples of forty acres, i.e., in multiples of quarter, quarter sections.

The implications of the exploration franchise procedure would be many and varied. The alternative would eliminate the mining claim as it is known today. It would also eliminate the use of production leases during the exploration phase. There would thus be no problem of undefined unpatented mining claims, nor would there be the problem of unsurveyed or poorly surveyed claims and fractional claims, if the franchises were awarded for areas defined by the established federal land survey in quarter, quarter section multiples. This alternative would simplify considerably the administration of the public land laws with respect to mineral resources. It would also make the administration of the public lands simpler in that it would not require any distinction or classification of land as to mineral or nonmineral. If a firm or individual were to apply for an exploration franchise for a given area of public land and be willing to pay the per acre fee for that franchise (which would guarantee no rights other than access and preference in the utilization of deposits discovered, for a limited length of time), this would be considered *prima facie* evidence that the land was potentially the site of a valuable mineral deposit. The franchise would not grant exclusive use of the land surface, but would provide prediscovery protection.

The primary impact upon state and local governments would be at the county level, where the need for the recording of unpatented mining claims would be eliminated. Other impacts on state and local government of this alternative would be essentially indirect, through effects on economic and other environmental factors.

The alternative would have manifold effects in national as well as regional and local economies. It would first make exploration for mineral resources on the public lands rewardable and tenure more secure. This could stimulate the search for mineral resources of all types and thereby enhance competition in mineral markets. The stimulation of the search for mineral resources on a uniform basis throughout the public land states could have a favorable impact upon many of the local economies in areas enriched in potential mineral deposits or at least those areas considered geologically attractive. The restriction to a maximum size for a franchise holder in the placement of specific acreage and time limitations on single franchises, as well as the imposition of a per-acre cost for the franchise, would tend to restrict monopolistic practices by minerals firms and enhance competition within the minerals industries. It would also severely limit, if not eliminate, the abuse of the mining laws for real estate speculation.

Specific requirements in the law regarding the effects upon the physical environment of exploration activities should delineate those effects considered adverse. The imposition of precise acreage limitations and per-acre fees for an exploration franchise, as well as the exclusion of nonmineral surface use rights, would tend to restrict activities by those persons not seriously seeking a mineral deposit. In particular, the position of a relatively short time limitation and the need for the performance of a specific amount of exploration work during any given time (if enforced) would tend to eliminate current abuses of the Mining Law of 1872 under which persons have used the pretext of a mining claim in order to gain the use of surface resources in selected areas. A requirement for the periodic reduction in the area included under any one exploration franchise would guarantee a maximum availability of land for both nonmineral users of the public lands and for other mineral users.

The alternative of a uniform exploration franchise with features as outlined should bring the public lands mineral law in closer conformance with the technical and economic realities of the mineral industries as they exist today and as they are likely to be for the next two decades. The area franchise concept is in conformance, not with the conditions of the 1860's, but with current exploration practice as it has been followed for the past two decades and as it is likely to be practiced for the next two. The franchise would give adequate prediscovery protection to the exploring firm or individual and would eliminate problems caused by vague titles to public land areas that are cluttered by the existence of unpatented claims whose status as abandoned or active is usually in question. It would eliminate the use of the lode and placer claim concepts and, in using a square or rectangular basic unit, be more in conformance with the structure of those orebodies being mined today and with the land requirements of other mineral-producing activities. The use of a minimal per-acre fee for the exploration franchise woud allow exploring firms or individuals to put a maximum amount of their capital investment into the acquisition of information about the nation's subsurface resources and minimize the amount that could be lost in not finding an economically valuable deposit. At the same time, it would prevent the mineral industries from acquiring more land for exploration than they might actually need by making it increasingly more expensive for them to do so.

This alternative, with the features as outlined, would also bring the law into closer conformance with geologic reality. It would make potential resources available to those firms or individuals most likely to utilize them upon discovery. It should also lead to a maximum availability of information about the geologic nature of the public lands, and thereby a more efficient allocation of total resources.

There are, of course, many variations possible for this alternative system. Specific features could be expanded, restricted, or eliminated. The acreage limitations could be changed, the time limitations could be changed, and the monetary dimension could be varied considerably. Each of the variations in the basic features of this alternative system would have its own implications and would have to be considered specifically. Such specifics are far beyond the scope of this study.

There are also alternatives to the entire system as stated. One is to continue to allow completely open exploration without any prediscovery protection. This would, in effect, continue the system established for mineral exploration for locatable minerals under the Mining Law of 1872. Of course, even now the system does not actually operate in accordance with that law. A continuance of this procedure would result, of course, in the continuance of the problems that have been created under it. Some modifications of that system are possible and undoubtedly highly desirable. As a minimum it probably would be advisable to require the registration of all unpatented mining claims as well as a plat map of them that is tied into the established public land survey. These should be registered with the nearest Bureau of Land Management Office, as well as in the appropriate county recorders' offices. Another alternative would involve the use of an *exploration claim,* which would be distinct from a *mining claim* in that it would entitle the holder or claimant to remove minerals only for testing and evaluation. Specific work requirements would have to be attached to any system involving an exploration claim, however, in order to prevent excess land speculation for nonmineral purposes under the exploration claim device. In many respects, an exploration claim would be an irregular open-ended, very-short-term exploration franchise at zero fee. The basic principles involved in both are similar.

At the other extreme, an alternative requiring the payment of a fee for any exploration rights on the public lands on a competitive bid basis for specific land areas could be considered. This feature, however, would tend to monopolistic practices by restricting exploration to those firms and individuals with the most money, i.e., those firms already well-established. It would thus restrict entry into the industry and create a definite tendency toward monopoly with resultant adverse consequences for the entire economy.

F. Land Acquisition for Minerals Production

One alternative for the treatment of public lands containing mineral resources (for the purpose of utilizing those resources) would be to permit any individual or firm desiring to produce minerals from the public land to purchase the land upon which those minerals are located. The price paid would be the appraised value of the *surface* resources. Preference in purchase for any given area would be given to the holder of an exploration franchise for that area. Any buyer of public lands for mineral purposes would be required to perform a specified amount of mine development work (excavation or drilling) within one year from the date of purchase or forfeit title back to the federal government. This alternative assumes, of course, that both the mineral rights and the surface rights for any given public land area are initially the property of the federal government. Under the alternative, no individual or firm would be allowed to purchase public land for minerals purposes without first securing an exploration franchise and conducting exploration operations under that franchise for at least one year.

The implications of this alternative for the administration of the public land law are essentially that such administration would be simplified. There would be no specific proof of discovery required. Prediscovery protection would be provided by the prior exploration franchise. Desire on the part of the franchise holder to pay for the surface resources at their current appraised market value (irrespective of the presence of any mineral resources) would be *prima facie* evidence of mineral discovery. The development work requirement would substantiate or refute it. The alternative could also eliminate a substantial amount (if not all) of the abuses of the present Mining Law perpetrated by those desirous of obtaining public land surface rights at a nominal fee. Of course, to eliminate these abuses, it would be necessary to establish the first year development work requirement at a substantial amount and also to make it proportional to the area involved. An expenditure requirement of $100 per acre in actual development work would not be an unrealistic standard under current conditions.

The immediate fiscal impact upon the federal government of this alternative would be to reduce the amounts received from minerals lease payments, but to increase the amounts received from the development of what are now *locatable* minerals on the public lands. Although lease bonus payment revenues would be decreased, the money that had been paid to the federal government under such arrangements would probably be diverted to productive uses in the further exploration and development of mineral property. This would contribute to the more rapid development of mineral production and should result, within a very few years, in increased tax revenues to the federal government, assuming no prior offsetting changes in the tax laws.

The impact on state and local governments under this alternative would be immediate and primarily financial in nature. The purchase by private interests of lands formerly held by the federal government would increase the tax base in each of those states and communities in which the land is situated. The alternative would also eliminate the need for keeping records on unpatented mining claims in the individual counties throughout the public land areas of the United States. Furthermore, abandoned unpatented claims would be eliminated as a problem because any land abandoned after production operations by those firms or individuals owning that land would become forfeit under tax obligations to the various counties, and title could be cleared under established procedures for tax liens.

The impact of this alternative on the national economy would be twofold. The first would be in the financial portion of the public sector, in decreased public revenues from leasing and bonus payments, but at the same time with increased tax revenues from profitable mineral-producing operations, as well as revenue from land sales by the federal government. The second facet of the impact of this alternative on the national economy would be to provide an incentive for a more appropriate allocation of investment capital, in placing in proper perspective both the surface and subsurface uses of any given piece of public land. Since the value of the mineral to be produced would have to be such as to compensate for the withdrawal of surface uses from their present status (if mining involved any surface disturbance), a better allocation of resources between competing uses of the public lands could be achieved.

At the state, local, and regional levels, the economic influences of this alternative would also have several aspects. One, as mentioned, would be through the public sector, in increasing the tax bases for state and local governments through the transfer of public land to private ownership. The second would be through the stimulus of mineral production where economically feasible and through the provision of incentives for obtaining the highest economic use of available land. In areas where metalliferous deposits are known or are considered likely to occur (i.e., in areas where the known mineral potential consists chiefly of minerals that are now *locatable*), the increase in mineral activity would probably be slight. Surface land uses would have to be given greater consideration in relation to subsurface uses, however, than is now the case. There is little doubt that considerable impetus would be given to the development of mineral resources in areas now devoted to the production of the so-called leaseable minerals. The optimum production of industrial minerals also should be stimulated by this alternative, however, under the consideration of proper allocation of resources between surface and subsurface uses of the land.

The requirement of this alternative, that the payment for lands containing mineral resources should take into consideration only the value of surface resources on that relevant land area, should considerably improve the relationships between the mineral resource user and the environment, both physical and social. This alternative would, in effect, force the quantitative measurement of competing uses of the land by transferring permanent ownership to the legitimate minerals producer. It would also enable and encourage the proper control of environmental factors during and after production operations. Continued ownership of mineral-producing land after principal production operations have ceased has proved to be a strong incentive for the further development, reclamation, or conversion of mined-out land to its most productive use, i.e., that use which will provide the greatest income to the landowner. There would probably be little or no impact upon the relationship between mineral production operations and the physical environment during active minerals production. These environmental influences, however, can (and probably should) be taken care of under other legislation, specifically designed for that purpose. The problems of atmospheric pollution should be dealt with under specific legislation and not as part of land law.

The primary impact of this alternative upon nonmineral users of the public land would be to place in quantitative perspective (on a dollar basis) the value of nonmineral uses of the surface, and thereby allow these uses to compete in the open market for land. The alternative would also eliminate abuses of the existing mining laws by those persons who declare minerals intent only as a means to gaining title or access to the surface of the public lands or to other resources, such as timber, located on those lands. There would be little or no impact upon the users of adjacent public or private lands by this alternative. Elimination of the problem of unpatented and abandoned mining claims, however, would facilitate use by other users of the public lands of surface lands not actually in minerals production by having those lands (once minerals production had ceased) revert to appropriate local public agencies or by allowing them to be resold to other private interests.

The major impact of this mineral land purchase alternative upon the nonfuel mineral industries would depend upon whether a particular firm or individual were now operating under the Mineral Leasing Act or under the basic Mining Law of 1872. For those firms or individuals producing minerals considered to be locatable, this alternative would force them to cease the use of the unpatented mining claim and to allocate sufficient funds for the purchase of all mineral lands that they would wish to use for minerals production and associated activities, in direct competition with other potential users of the public lands. Transfer of complete ownership of all subsurface and surface rights to the minerals producer would also encourage the maximum utilization of land held by the minerals producer, both during and after production operations. The fact that mineral-bearing lands would be held in fee simple would also assure the minerals producer and developer of complete protection of his rights in the further exploration and development of that land. For those producers operating under the leasing laws, the immediate impact would be to eliminate the necessity for competitive bidding on an unknown quantity, i.e., the placement of competitive bids for unexplored land. It would also (as under the locatable minerals) require them to give due consideration to the surface value of land used for mineral purposes and to the reclamation or conversion to a higher utilization of that land upon cessation of production operations. In both instances, that of both locatable and leaseable minerals, this alternative would restrict monopolistic tendencies towards the acquisition of more land than needed for appropriate mineral development and production by forcing mineral producers to compete with other users of the land. In some instances, it would probably encourage the advancement of underground mining techniques or other methods of mining that would tend to cause a minimum disturbance of the surface. This would be particularly true where the value of surface uses was substantial.

This alternative, in some instances, would reduce the availability of mineral resources, particularly of locatable minerals, while at the same time increasing the potential reserves of leaseable minerals. In the first instance, reserves would be reduced by the requirement that the value of subsurface resources would have to be high enough to offset the value in other uses of the surface of the land. In the second instance, it would allow greater exploration and development without regard to excessive bonus payments, rentals, or royalties paid on industrial minerals land, particularly in areas of low surface value. In areas of potential multiple use of the land, such as those on which sand and gravel deposits are found in the fringes of established urban areas, the mineral land purchase alternative would probably increase the availability of mineral resources by allowing multiple returns to be made from a single purchase price of the land, i.e., from the extraction of the mineral resource itself and then from subsequent development for the surface use of the land. The alternative puts the law in much closer accord with economic, geologic, and engineering reality in permitting a proper allocation of values to subsurface and surface utilization of the public lands, and in eliminating the often inflated prices paid for unknown (and sometimes known) minerals under the bonus bid and leasing system.

There are, of course, a number of variations to this mineral land purchase alternative. One of the basic alternatives is the present system for locatable minerals under which ownership of minerals and use of the surface are obtained for mineral development purposes by the payment of a nominal fee or not at all. The results of this alternative on the environment, upon the federal government, upon state and local governments, and upon the mineral industries themselves have been recorded over the past 100 years. The nominal or zero payment for surface lands has certainly encouraged the development of nonfuel mineral resources, primarily of those metallic ores that are considered locatable. On the other hand, it has also led to abuses of the law by those desirous of obtaining surface rights through distortion of the mining laws that has frequently been permitted by administrative agencies and the courts. The payment of a nominal fee for mineral-containing lands does not allow the proper allocation of resources and priorities between surface and subsurface uses of the land. This has already caused some minor conflict in urban areas and is likely to cause much more conflict in the future.

The other extreme variation of this alternative is to not transfer title in fee simple to the minerals producer, but simply to lease the desired mineral land to him for payment of a rental consistent with the value of either the surface resources or the surface and mineral resources on either a competitive basis or first-come, first-served fixed amount basis. The lease arrangement, if for a long enough term and if for a fixed amount, would be similar in many respects to a simple transfer of title in fee simple for a fixed purchase price paid in installments. If the lease is short-term, however, it removes from the owner some of the guarantees that he would otherwise have if the land were owned by him. Likewise, it removes some of the incentives for converting the land to the highest economical use once mineral-producing operations have ceased. The lease arrangement also diminishes the tax base of state and local governments by not transferring any land to private ownership. Competitive leasing removes the protection accorded to the minerals explorer and developer and, in effect, removes any strong incentive for mineral development, except where the potential gains are extremely high. In such cases, the element of monopoly profits becomes extremely strong and tends to misallocate investment capital. This has already been the case in the petroleum industry.

G. Elimination of Distinction Between Public Domain and Acquired Public Lands

Under this alternative, all public lands would be considered alike, regardless of their location and regardless of their status as acquired or original public domain. Public lands on which the surface use by the federal government is specific with respect to governmental activity and thereby precludes mining activity (e.g., national defense installations, national parks and monuments, post office sites) shall not be considered *public land* but shall be termed *federal land*. This alternative would simply remove from potential mineral development under any proposed or existing system those lands used for particular governmental purposes, that is, for those functions normally considered the prerogative of the federal government, such as national defense activity, governmental buildings, national parks and monuments, historic sites, and so forth. It would not include those lands on which, although the government may have control, the activities conducted thereon are normally performed by private enterprise. This would include primarily the National Forests and all those lands now administered by the Bureau of Land Management.

The direct impact of this alternative on the federal administration of the public land laws would be to simplify administrative procedures by removing the distinctions that now exist under various laws between acquired public land and public domain. It would, in effect, increase the public domain and make all policies and laws presently applicable to the public domain applicable to all public lands (except those designated *federal lands*). The alternative should, of course, also allow for transfer back to public domain of lands specifically reserved for such activities as national defense installations or atomic energy tests sites, once those particular activities are no longer being conducted. This alternative would, in effect, make all public lands not used for specific government purposes subject to the public land mineral law alternatives discussed previously.

The effects of this particular alternative on state and local governments would be nil. The effect on the economy at the national level would be minor and would result primarily from the elimination of excess costs involved in the administration of the public lands, as well as in the elimination of certain revenues obtained from the sale or lease of mineral commodities from *acquired land* now held by the government of such minerals that are normally considered locatable under the existing *public domain* legislation. The effects on state and local governments would be essentially minimal and only those resulting from the revenue sharing practices pertinent to mineral revenues received on acquired land.

The impact of this alternative on the physical and social environments under which the producers of mineral resources on the public lands operate would be nil. The effect on the mineral industries themselves would be to simplify exploration, land acquisition, and mineral development practice. The alternative would have virtually no effect on the mineral resources of the United States themselves, except to place those mineral resources on acquired land in the same political and legal status as those on public domain lands. This would place the law in much closer conformance with geological and technical reality.

There are, of course, variations to this alternative. The major one is the continuation of the present system under which acquired lands are distinguished from original public domain, depending upon the particular legislation under which they are acquired. This has led to considerable confusion and a multiplicity of variable practices and policies for public lands which are, in other terms, not at all distinguishable. The implications of this variation, the continuance of the present system of distinction between public domain and acquired land, is that the existing confusion in minerals exploration, acquisition, and production would be continued and probably heightened as more lands are acquired for public use under future legislation.

H. All Public Lands Administered by a Single Federal Agency

Under this alternative, all public lands would be administered by a single agency of the Department of the Interior. This would include those *public* lands now administered by the Department of Agriculture, but it would not include those *federal lands* administered by the Department of Defense, the General Services Administration, or the Atomic Energy Commission for specific nuclear testing. Under this alternative, prime responsibility for the public lands would be held within one executive department by one administrative agency.

This agency would administer all public lands open to exploration and acquisition for mineral purposes.

The implications of this alternative would be felt primarily in the federal administration of the public land laws regarding mineral resources. The alternative would either eliminate the United States Forest Service as a separate agency of the Department of Agriculture and incorporate it within the Department of Interior, or withdraw all of those areas administered by the Forest Service from possible mineral exploration and acquisition and formally make forestry and grazing a specific activity of the federal government. The more logical of these two courses of action, of course, is to place the land areas now included within the National Forests within the jurisdiction of the Department of the Interior. Such a move would be likely to have numerous and varied implications and repercussions within the federal government. It would, however, result in considerable simplification and greater coherence in public land minerals policy and procedures, and would result in the fixing of primary responsibility for mineral activities within the national forests, eliminating the dual responsibilities now shared by both the Bureau of Land Management and the Forest Service.

The impact of this alternative on state and local government would probably be nil. The impact on local and regional economies would probably also be slight, except as the consolidation of federal agencies might diminish federal employment in local areas now administered by the Forest Service. The direct effect on the national economy would also probably be relatively slight and would come through the consolidation of federal agencies and the resulting cost reductions to the federal taxpayer. At the local and regional levels, however, there could be a significant impact resulting from changes in federal agency policy towards competing uses of those areas now included within the National Forests. The alternative would probably result in a greater incentive toward the true multiple use of public land areas and the "highest and best" use of the public land.

The effects of this alternative upon the relationships between the mineral industries and the physical and social environment would probably be minimal. The same would be true for the relationships between mineral users of the public lands and nonmineral users of the public lands except in those areas where Forest Service administration has resulted in preferential treatment for certain types of nonmineral users. This alternative would probably result in a more appropriate balance between competing and complimentary uses of the public lands.

The impact of the alternative upon the mineral industries themselves would be to enhance the conduct of mineral exploration, development, and production operations on those portions of the public lands now controlled by the United States Forest Service. It would probably also provide a greater incentive to the small minerals producer in these areas and would remove the existing preference given to large mineral producers. It could also result in the elimination of the abuses occasioned by the excessive use of free-use permits on Forest Service land. The probable impact upon the mineral resources of the United States would be an increase in their availability. It would undoubtedly place the administration of the federal public land laws, as they pertain to mineral resource exploration, development, and production, in much closer conformity with geologic, technical, and economic reality.

The major variation of this alternative is, of course, to retain the existing distinction between those lands administered by the Forest Service of the Department of Agriculture and those lands administered by the Bureau of Land Management in the Department of the Interior. The continuation of this arrangement would mean a continuation of the present distinction in mineral policy on those two portions of the public lands and probably would result in continued abuses of administrative authority by the Forest Service.

One problem that would probably arise at this point, particularly in view of the other alternatives already described, would result from a situation in which a significant mineral discovery is made on Forest Service land under an exploratition franchise and is then followed by a request from the discoverer for the purchase of that land for mineral purposes. It could be said that since the particular area desired is National Forest land, it should not be sold to a private interest. In the light of the primary purpose of a National Forest, however, if any land now in a National Forest area can be considered to have a higher value as a mineral-producing area, there is strong justification for advocating that it probably should be removed from the National Forest. This assumes that the value of its subsurface resources are significantly greater than the value of its surface resources. For those areas considered worthy of preservation as wilderness or primitive areas, it would undoubtedly be more consistent with physical reality and with the purpose of the delineation of those areas to place them within the administration of the National Park Service and remove them from status as *public lands*. This would make them essentially *federal lands*, and would declare the preservation of a wilderness or primitive area as a specific federal activity. Such a procedure would require that serious consideration be given to the alternative uses of any given portion of land that is now in the public land category. The implications of this alternative and the variations of it are indeed far-reaching, and they are largely political in nature. The long-range economic aspects of the proper allocation of the limited land and other natural resources of the nation are also directly involved, however.

I. All Minerals to be Considered Alike

It has been implied in the alternatives to the existing public land system already described that there should be no distinction between the various mineral commodities. In other instances, the need for some distinction has been implied. Under this alternative feature, at least all nonfuel minerals would be considered the same, and no distinctions would be made between them or between any classes of them. This alternative could also be expanded to include the fuel minerals as well, and the most reasonable variation would include coal and oil shale, along with the nonfuel minerals. In other words, all *solid minerals* would be included in one minerals category.

The implications of this alternative for the federal administration of the public land laws with respect to mineral resources would be to simplify that administration and to diminish considerably the need for distinctions between specific mineral commodities and specific mineral deposits. Some of these existing distinctions are highly questionable, and their use is even more questionable. The impact of the alternative on state and local governments would probably be unnoticeable, except where revenues from lease payments and royalty payments for leaseable minerals are currently shared with those state and local governments. The alternative would do away with the distinctions between locatable minerals, leaseable minerals, and disposable minerals.

The economic effects of this alternative would be several. In the public sector, the cost of public land administration would be decreased through simplification of the necessary administration of the law. At the same time, revenues received from mineral leasing could either be decreased (if all minerals were considered not leaseable) or increased (if all minerals were considered to be leaseable). The impact on national, local, and regional governments, then, would primarily depend upon the other provisions of the public land laws regarding mineral resources.

The effects of this alternative on the relationships between the minerals industries and the physical and social environments would also depend upon other specific provisions of any public lands mineral system. This would also be true for the relationships between users of the public lands mineral resources and nonmineral users. For the mineral industries themselves, this alternative would result essentially in a simplification of exploration, development, and production procedures, depending, of course, upon the other specific provisions of public land mineral legislation. Whether or not it would provide an incentive to increased mineral production would depend upon how all minerals were treated under a single category, and not simply with the fact that all were considered alike. The same would be true of the relationships between the mineral resources themselves and the law.

Placing all solid minerals under a single category for equivalent consideration under the law brings that law in much closer conformance with geologic reality. If, however, other features of the public land mineral law then proceed to treat all of those minerals in an unrealistic manner, this advantage is lost. Probably the only distinction between the various mineral resources that is in conformance with geologic reality would be a distinction based upon the physical state of those minerals in place within the earth, either as solids or as fluids. In some respects, however, unconsolidated materials such as sand and gravel could be considered fluid, and this would be a reasonable distinction in many respects. Nevertheless, with the development of solution mining techniques, even such a distinction as that between fluids and solids could cause some problems in the administration of the public land mineral laws.

Many variations to this alternative exist. In fact, there are as many variations as there are minerals. The most extreme variation would be to consider every mineral as distinct from every other mineral. This extreme may appear ridiculous in the light of geologic reality and the similar characteristics of many deposits of dissimilar minerals. Nevertheless, an approach has been made to such complete distinction in the existing system by the treatment of different minerals in different ways under separate pieces of public land legislation. The implication of these sometimes artifical distinctions between similar commodities is to generate considerable confusion in the search for and utilization of mineral resources on the public lands, particularly where two minerals of different categories are intermingled in the same deposit.

The other extreme is to consider all minerals, both fuel and nonfuel, as well as other subsurface resources including geothermal steam and water, in the same category. The particular characteristics of certain subsurface resources such as water, however, make this unrealistic politically, economically, technically, and geologically. There are, nevertheless, significant justifications for the treatment of petroleum, natural gas, helium, and otherwise fluid subsurface resources as similar enough to those subsurface commodities which exist in a solid state. Such an all-inclusive consideration of all minerals, to be effective or meaningful under the public land laws, would have to be carried through to other types of legislation, and in particular to the tax laws.

J. Public Land Information Requirements

As one feature of any alternative system of public land mineral law, the federal government could be required to make accurate, basic geographic and geological information available to potential users of mineral resources on the public lands. Under one variation of this alternative, the federal government would be required, through the United States Geological Survey, to provide accurate, topographic, and basic surface geology maps of all land in the public domain of the United States. Copies of these maps would be available upon request to interested parties for the cost of printing and handling. In addition to these basic maps, other maps containing basic geophyscial data such as magnetometer and gravimetric readings would also be made available for large areas. A program for the provision of basic, large-area, background geochemical data would also be instituted through the United States Geological Survey. This alternative would make the United States Geological Survey a provider of basic mineral resource and surface resource information.

In many respects, this alternative is simply a statement of the functions of the Geological Survey as they exist today. In other respects, however, it is a restriction of certain of their operations and yet also an expansion of certain operations. The effects of these possible restrictions and expansions would be several. There would be an initial direct impact upon the federal government itself by this alternative feature which would make the federal government a provider of basic natural resource information. The requirement that the federal government provide basic background information of a geophysical and geochemical nature for large areas of the public lands would, in effect, be an expansion of existing responsibilities. The direct impact of this requirement would be to expand federal activities on the public lands. On the other hand, in certain respects this alternative (along with other features of the system being evaluated) would remove certain functions from the federal government including those involved directly in the search for specific minerals and in the classification of lands as *mineral* or *nonmineral.* The removal of such functions from the Geological Survey would curtail government operations to the extent of those functions. The net effect, however, would probably be an expansion of the activities and personnel of the Geological Survey.

The major impact of this alternative on state and local governments would be essentially indirect. Nevertheless, the definition of activities carried on by the United States Geological Survey with regard to the public lands would have, in many instances, a direct relationship to the activities carried on by state geological and mineral resource departments. Whether or not the activities of such state departments were coordinated with activities at the federal level would depend upon the various state governments involved. The portion of the alternative that would require the completion of the Public Lands Survey would have its greatest direct impact upon local governments in those unsurveyed areas.

The primary effects of this alternative upon the economic environment would be favorable. The direct provision of additional information regarding the surface and subsurface characteristics of the public lands of the United States should stimulate (all other things being equal) activity upon those public lands. This would have an impact on national, regional, state, and local economies. The extent of the stimulus to local and state economies provided by increased activity on the public lands would depend upon the nature of existing information regarding the public land in those states and localities. The greatest impact of the information requirement would be in lands were information now is relatively sparse, and it would be least in areas where abundant information is already available. Likewise, it would be impossible to provide all of the information on all of the public lands at the same time. Thus, the initial impact of the requirement of this alternative would be felt first in those areas where such information programs were first instituted.

The impact of the information requirement of this alternative on the relationships of the mineral industries and the physical and social environment within which they operate on the public lands would be generally beneficial. The provision of accurate basic data, particularly topographic and surface geology information, should enable the presentation of an accurate and complete picture of the relationship between the mineral resources and other resources on the public lands. This would also be true of the relationships between the users of mineral resources on the public lands and other users, both existing and potential, of those same lands.

The impact of this alternative on the mineral industries themselves would be to provide a stimulus to additional search for mineral resources and the more effective utilization of known mineral resources on the public lands, particularly in areas where basic geographic and geologic data are not now available. This would be particularly true of areas that have not yet been included within the Public Land Survey. With respect to the mineral resources themselves, the requirement would, in effect, make additional resources available to proper and effective utilization by the mineral industries. The requirement would certainly bring the law and the administrative activities of the federal government in much closer conformance with geologic and other physical reality.

There are basically two variations of this information alternative. One would be to severely limit the amount of information about the public lands to be supplied to the general public by the federal government or its administering agency for the public lands. The effects of this variation would undoubtedly be adverse, both as to the development of the mineral resources on the public lands and also for the effective adminstration of those lands. Adequate and complete basic information is a necessary adjunct to the effective administration of any federal property. The other variation of the alternative would involve the Geological Survey or other federal agencies in the provision of information other than that resulting from fundamental or basic research activities. To a certain extent, this has already been done in certain applied research activities of the Geological Survey and the Bureau of Mines, most specifically in their programs involving specific mineral commodities. In effect, under this variation of the alternative, they would be engaged in active minerals reconnaissance and detailed exploration with the information to be made immediately available to the general public. This has not been a successful function of the United States government in recent decades, its failure to find new uranium deposits being the most notorious example.

This alternative would put the federal government (through these agencies) in direct competition with private firms and individuals engaged in minerals exploration. It would also tend to have an effect on the federal government itself, in channelling resources, time, and personnel to specific areas of the United States where favorable indications for the presence of selected minerals had been or might be found. This could lead to a general neglect of other areas of the public land. This has, in fact, already happened, as evidenced by the relatively large extent of public land areas in the Western United States that still have not been made a part of the Public Lands Survey. There have also been adverse economic effects resulting from the practice of this variation in the past. In certain areas, the publication of geologic, geophysical, and geochemical data with respect to the occurrence of specific valuable minerals in specific locations has resulted in inflated land prices and made effective utilization of those minerals in those areas difficult for private interests. This adverse consequence of detailed minerals exploration activity by the federal government could be expected to continue and perhaps become even more severe.

K. Centralized Recording of Public Land Status Information

Under this alternative, the federal government would be required to keep, in at least one central place in each state of the United States, an accurate appraisal of the current tenure status of all public land, and this information would be available to the general public without charge. This alternative would, in effect, continue the present program operated by the Bureau of Land Management in its various state offices, and improve it where necessary. The alternative would also curtail the need for the filing and maintenance of records regarding mineral land status in the county recorders' offices of each county in the public land states.

The implications of this alternative feature for the federal government would be directed towards the administration of public lands by the Bureau of Land Management. It would result in a consistency of operation within the Bureau of Land Management state offices and should result in an improvement of recordkeeping and land status information operation. The initial effect would be an expansion of activities in the state offices of the Bureau of Land Management to the extent necessary to modernize existing records and improve the availability of information services to the general public. The most direct impact upon local governments would be just the reverse, with the major effect being felt at the county government level where the need for the recording and filing of mining claims would be eliminated. For some counties in the West, this would result in a major decrease in responsibilities regarding the provision of information about the public land. The direct impact on state government would be essentially neutral.

The effects on the public sector of the economy of this centralized records alternative would probably be offsetting. Increased federal expenditures would be required in the various state capitals or other centralized locations within each state resulting from an expansion of Bureau of Land Management activities. These would be countered, however, by what would probably be complementary reductions in the expenditures necessary by county governments in the maintenance of public land mineral records. The impact on the private economy would be essentially a reduction of costs involved in mineral land acquisition by private interests in that the cost of clearing title and obtaining information about the public lands regarding their mineral resources and tenure status would be reduced. For some areas, and for some firms, this cost reduction would be considerable.

The effects of this centralized records alternative on the relationships between the mineral resources of the public lands and the physical and social environment probably would be neutral. The same can be said for the effects of the alternative on the relationships between nonmineral users of the land and mineral resource users. The feature, however, would make identification of mineral and nonmineral resource users much easier.

The major impact of this alternative on the mineral industries themselves would be to reduce the cost of mineral land acquisition and in particular the cost of determining the status of public lands with respect to mineral resources. It should also, by making more complete information more readily available in a centralized and accessible location, provide an incentive to more complete competition for the public lands among existing and potential mineral resource users. As far as the impact of the alternative on the mineral resources themselves is concerned, this alternative should make a greater amount of mineral resources on the public lands more readily available to both existing and potential resource users.

One of the possible variations to this alternative feature (and which has been practiced in the past) is the continuing maintenance of information regarding public land status with regard to mineral claims available only at the county level. The effects of this practice have been several. One of these has been to remove from the federal agency directly responsible for the administration of the public lands the information about those public lands that it vitally needs for its administration to be effective. The other impact has been on local governments in making additional requirements upon their already overtaxed facilities in providing and maintaining information about federal lands. Because every county government in the United States is operated in a somewhat different manner, the maintenance of records by the counties has resulted in a wide variation in the type and relative completeness of public lands mineral status records. This has tended to make the search for and the acquisition of mineral resources on the public lands of the United States more difficult for private interests desirous of developing the mineral resources of the public lands.

The other extreme variation of this alternative is to have all public land information available and maintained only at the national headquarters of the Bureau of Land Management in Washington, D.C., or at best, at a regional headquarters somewhere in the public lands states of the West. The implications of this variation should be obvious. It would, through the extreme centralization of information, restrict the availability of that information to the general public and to existing and potential mineral resource users. This increase in the difficulty of access to necessary information would have a detrimental effect upon the utilization of mineral resources on the public lands of the United States.

The possible range of alternatives has only been touched upon briefly in this summary. The full range of possible alternatives and their specific dimensions is enormous, and the problems with which they deal are extensive and complex. More detailed discussion of these problems and their alternative solutions are contained in Chapters 16 and 17 of the full report, while the factual data relevant to the various legal systems are in Chapters 2 through 14.

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History of Public Land Law Development. Written by Professors Paul Wallace Gates of Cornell University and Robert W. Swenson of the University of Utah. 1968. $8.25

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Study of Withdrawals and Reservations of Public Domain Lands. Prepared by Charles F. Wheatley, Jr. Revised September, 1969. Order numbers: P B 187 002, P B 187 003, P B 187 004.

Administrative Procedures and the Public Lands. Prepared by The University of Virginia, School of Law. Revised September, 1969. One volume. Order number: P B 187 205.

Fish and Wildlife Resources on the Public Lands. Prepared by the Department of Fishery and Wildlife Biology, Colorado State University. Revised September, 1969. Two volumes. Order number: P B 187 246, P B 187 247.

Public Land Timber Policy. By George Banshaf & Company, Milwaukee, Wisconsin. Published in four volumes, Nos. PB 187 728, PB 187 729, PB 187 730, PB 187 731.

Federal Public Land Laws and Policies Relating to Intensive Agriculture. Resources portion by South Dakota State University. Legal portion by Kronick, Moskovitz, Tiedemann & Girard, Sacramento, California. Published in four volumes. Legal portion, Volume I, No. PB 188 061; resources portion, Volumes II, III, and IV, Nos. PB 188 062, PB 188 063, PB 188 064.

Development, Managment and Use of Water Resources on the Public Lands. By Charles F. Wheatley, Jr. Washington, D.C., Charles E. Corker of the University of Washington, Thomas M. Stetson, San Francisco, California, and Daniel J. Reed, Los Angeles, California. Published in two volumes, Nos. PB 188 065, PB 188 066.

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Regional and Local Land Use Planning. By Herman D. Ruth & Associates, Berkeley, California. Published in four volumes, Nos. PB 189 410, PB 189 411, PB 189 412, PB 189 413.

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